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ENGINEERING DIVISION
AIR SERVICE

DAYTON, OHIO

TECHNICAL ORDERS
No. 16

MAY, 1920

TECHNICAL ORDERS

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ENGINEERING DIVISION

AIR SERVICE

DAYTON, OHIO

Technical Orders No. 16

McCOOK FIELD
May, 1920

This publication is issued monthly. Its purpose is to furnish the Air Service a resume' of the status of aviation material for the preceding month.

By direction of Major-General Menoher.

THURMAN H. BANE,
Major, Air Service.

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APPLIED DESIGN

AIRPLANES

APPLIED DESIGN

Type I—Single Seater Pursuit

Orenco Type "D," Engineering Divisions alterations have been completed.

Contract pending with the Curtiss Engineering Corporation for production order of fifty Orenco Type "D" airplanes with necessary spares.

Orenco Model D-2—Contract with the Ordnance Engineering Corporation for three experimental airplanes progressing satisfactorily. Mockup under construction.

Lewis & Vought Model VE-8—Second airplane delivered to McCook Field for performance tests.

Engineering Division Model VCP-1A—Preliminary design to incorporate revisions for correction of balance completed.

Thomas-Morse MB-3—Contract pending with the Thomas-Morse Aircraft Corporation for production of fifty of this type of airplanes with necessary spare parts.

Loening Monoplane—Contract with the Loening Aeronautical Engineering Corporation for experimental construction of three airplanes progressing satisfactorily. Drawings and mockup are in process.

Type II—Single Seater Pursuit for Night Work

Contract with the Curtiss Aeroplane & Motor Corporation for three experimental airplanes progressing satisfactorily. Revised mockup nearing completion; all preliminary design and performance data received; wing and empennage drawings in progress.

Type III—Single Seater Pursuit

No further action since last report.

Type IV—Armored Pursuit

Engineering Division Model GPX—Drawings of a design to meet the requirements of this type are in progress and about 50% completed.

Type V—Two Seater Pursuit

No further action since last report.

Type VI—Three Seater for Ground Attack

Engineering Division Model GAX—Undergoing modification before completion of performance tests. Bids have been received and opened for a small production order of this airplane.

Type VII—Two Seater Infantry Liaison (Armored)

Engineering Division re-design of the LePere GH-11 has been assembled for performance tests.

Orenco Model E—Contract with the Ordnance Engineering Corporation for experimental construction of two airplanes is progressing satisfactorily—about 37½% complete.

Type VIII—Two Seater Night Reconnaissance

Engineering Division Model XB-1A—Two airplanes under construction to satisfy requirements of both Type VIII and Type X.

Type IX—Three Seater Army and Coast Artillery Observation and Surveillance

No further action since last report.

Type X—Two Seater Corps Observation

Engineering Division Model XB-1A—Bids have been received and opened on the production order of this type airplane.

Empire Metal Aircraft Corporation—Contract for experimental construction of four airplanes progressing satisfactorily. The assembly of the first airplane is practically completed.

Type XI—Day Bombardment

No further action since last report.

Type XII—Night Bombardment—Short Distance

Contract pending with the Glenn Martin Company for a production order of twenty airplanes of an improved design of the Martin bomber.

Type XIII—Night Bombardment—Long Distance

Bids have been received and opened on a design by Mr. Barling, of the Engineering Division, for the experimental construction of two airplanes of this type.

Type XIV—Training (Air-Cooled Engine)

No further action since last report.

Type XV—Training (Water-Cooled Engine)

Engineering Division Model XT-3—Drawings are in progress on airplane to meet the requirements of this type and are about 60% complete.

Miscellaneous Design

Gordon-Bennet Entry—Engineering Division VCP-R—Preliminary design has been completed and detailed drawings have started, and work in the shop to modify present model is well under way.

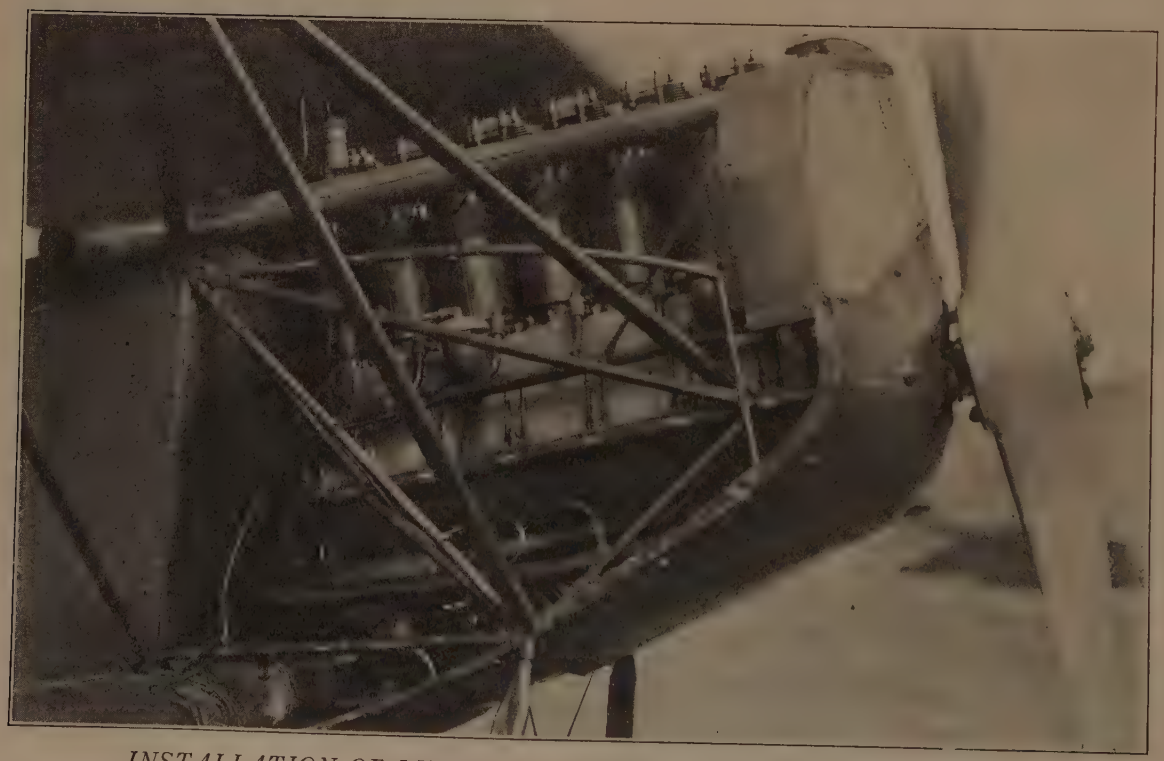
Performance tests of Fokker D-VII equipped with the 6-cylinder Liberty Engine gave the following results:

Weight empty (including water)	1538 lbs.
Armament and Equipment	285 lbs.
Crew	180 lbs.
Gasoline	156 lbs.
Oil	20 lbs.
Gross weight	2179 lbs.
Area	91 sq. ft.
Weight/square foot	9.24 lbs.
Weight/horsepower	9.48 lbs.

Standard Altitude in Feet.	CLIMB			SPEED	
	Time in Min.	R.P.M.	Rate Ft./Min.	M.P.H.	R.P.M.
0		1555	1050	120	1750
6,500	7.7	1540	660	115	1670
10,000	14.2	1520	450	111	1615
15,000	32.4	1470	150	97	1510
15,900 Service Ceiling 17,500	39.9	1460	100	92	1490
Absolute Ceiling		1430	0	76	1430

THREE-QUARTER REAR VIEW OF FOKKER (LIBERTY "6") D-VII

SIDE VIEW OF FOKKER (LIBERTY "6") D-VII



INSTALLATION OF LIBERTY "6" ENGINE IN THE FOKKER D-VII

ARMAMENT

APPLIED DESIGN

Development of an electrical synchronizer is progressing very satisfactorily and a modified generator tested by the Engineering Division gave very satisfactory results.

* * * *

An automatic compensator for advancing the time of fire at high speeds, so that the shots at these speeds will fall approximately in the same position as the shots at low speeds, has been designed and tested. Tests of this device proved very satisfactory and approximately 70° advance has been obtained for the shots fired at 1500 R.P.M.

* * * *

A design of a special generator, which will drive from the Nelson Gun control drive upon the standard types of engines, is in progress.

* * * *

A single shot trigger motor for the Vickers gun, which will operate on it through the Nelson gun control without any alteration of the gun itself, has been completed and is being fitted to the Vickers gun for tests.

* * * *

Experimental apparatus is being designed to test a new sight compensating device, which will compensate for both the speed of the target, and the airplane doing the firing.

* * * *

A series of tests have been completed to determine the effect of 37 mm. high explosive ammunition on airplanes and airplane wings, and report is being prepared.

* * * *

Three designs of bomb release handles have been completed. These are so arranged that a minimum of one bomb and a maximum of six bombs may be dropped with one movement of the handle. Two of these designs are provided with salvo levers, by means of which all bombs may be dropped at one time by one movement of the lever. These handles are provided with an indicating and registering device, which registers the number of bombs dropped, as well as the number remaining in the trap, and also indicates the weight of the bombs.

EQUIPMENT

APPLIED DESIGN

Experimental tests are being conducted to determine the accuracy of the radio goniometer station for Coast Defense. Work by outside contractors on construction of eleven additional stations is progressing satisfactorily.

* * * *

Laboratory tests are being conducted on the Lockwood radio control for airplanes.

* * * *

Drawings of a constant pressure cockpit are under way.

ENGINES

APPLIED DESIGN

Air-Cooled Engines

Designs and bids have been received on a 350-H.P. air-cooled radial engine. Designs submitted were of considerable interest, and after careful analysis, two of the designs were selected, and contracts are pending for experimental orders for each of these two designs.

* * * *

18-Cylinder W.

Construction of the model "W" engine is progressing as satisfactorily as can be expected under present industrial conditions.

* * * *

Packard Engines

The Packard 1A-1116 has satisfactorily completed its 50-hour endurance test, and no serious trouble was encountered at any time during the test. Inspection, however, shows the babbitt in all connecting rod bearings to be in very bad condition.

The first Packard IA-2025 engine, 550 H.P., has been received and is prepared for dynamometer test.

* * * *

Cooling Systems

A test of the Fokker D-VII with Mercedes engine indicated that the radiator is about 31% too small for the average temperature conditions in the United States.

STANDARD ENGINE REPORT ON PACKARD MODEL 1A-744 AVIATION ENGINE

Summary

Normal B.H.P. at full throttle.....	179.5 at 1600 R.P.M.
Fuel consumption at normal B.H.P.....	0.484 lb. per H.P.H.
Oil consumption at normal B.H.P.....	0.056 lb. per H.P.H.
Normal B.M.E.P.	119.5 lb. per sq. in. at 1600 R.P.M.
Weight, dry, with hub and storage battery	541.8 lb.
	3.02 lb. per B.H.P. at normal power.

Conclusions

No definite conclusions are possible as to the suitability of this engine for service training use until it has been subjected to a fifty-hour endurance test, which is now being made.

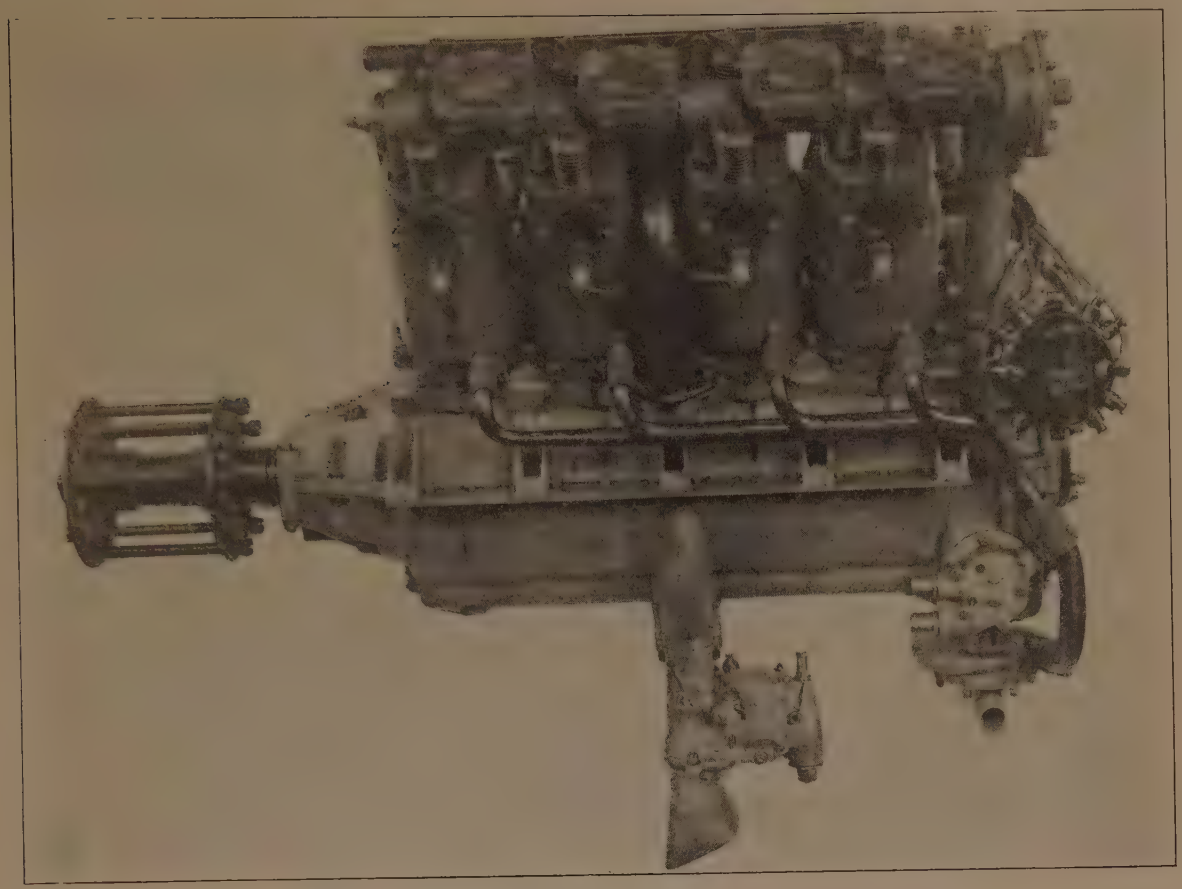
Description of Engine

Type—The Packard Model 1A-744 aviation engine has eight cylinders arranged in two rows of four each with a 60° included angle. It is water-cooled and operates on the four-stroke cycle with gasoline as fuel.

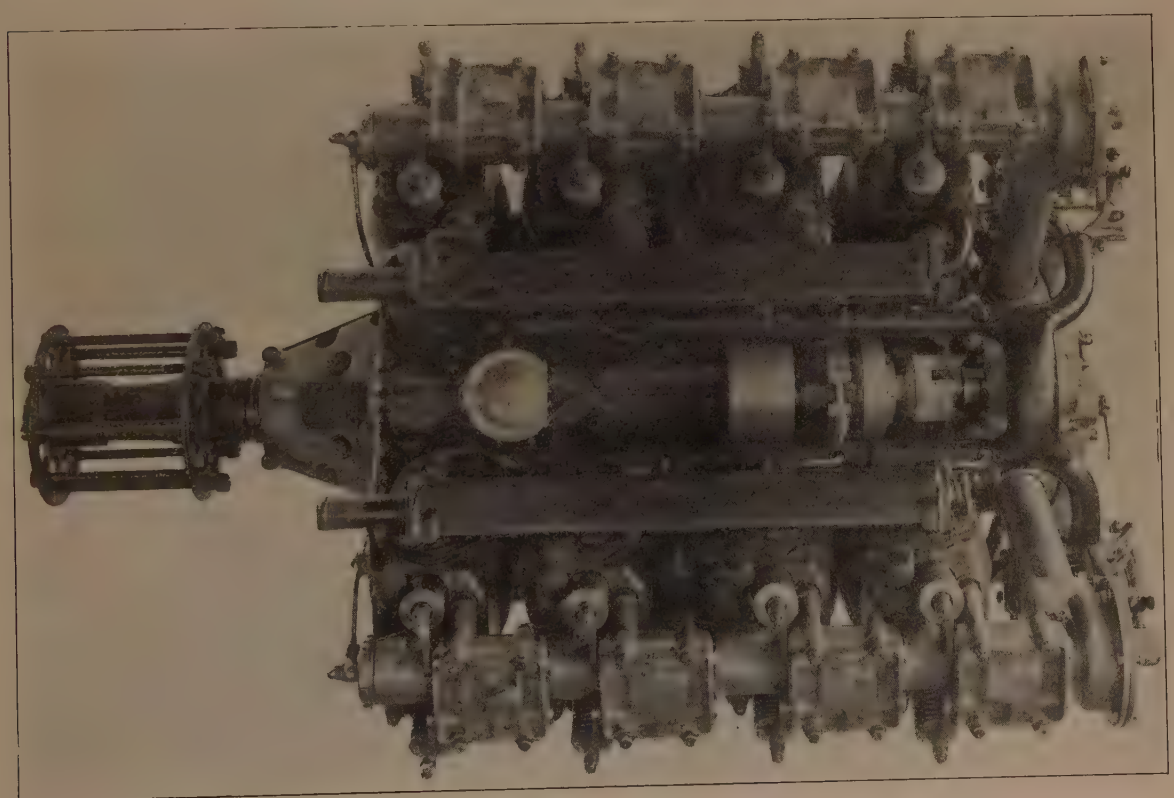
Manufacture—The engine is manufactured by the Packard Motor Car Company, of Detroit, Michigan.

Characteristic Features—The characteristic features of this engine are its built-up steel cylinders with welded water jackets of sheet iron stampings, the overhead valves, camshafts, and valve gear, the underneath carburetor with induction pipes through the crankcase, external and removable oil pressure adjustment valves and battery-generator ignition. In connection with the following description, attention is invited to the accompanying photographs, drawings, and tables of dimensions and weights.

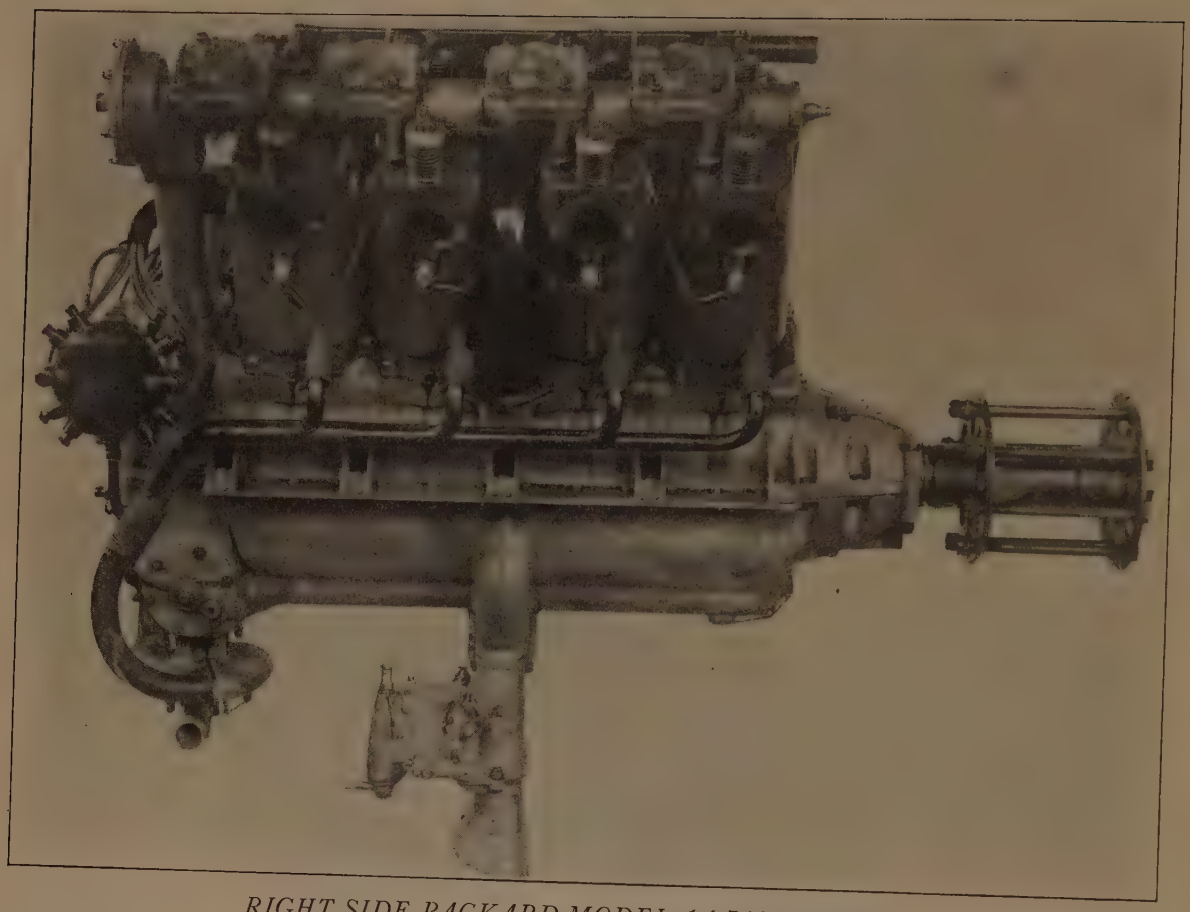
Crankcase—The crankcase is in two pieces parted in a horizontal plane at the crankshaft, and lapped at the joint. It is of single web, box girder construction. The outside of the upper case is buttressed, and forms the mounting flange of the engine. Through-bolts position the two cases with respect to each other, and bolt them together. A number of small bolts and nuts also clamp the cases at the flange. The crankshaft bearings are doweled to scraped surfaces in the webs. The lower case contains two small compartments located side by side beneath the gear compartment. One of these is for the oil pump, and the other for the pressure relief and adjustment valve assembly.



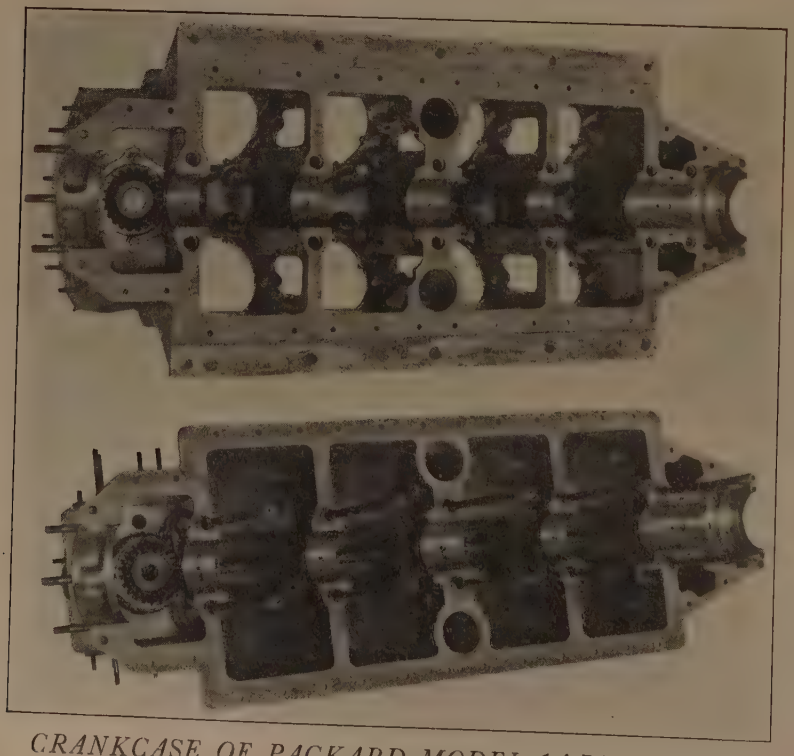
LEFT SIDE PACKARD MODEL 1A-744 ENGINE



TOP VIEW PACKARD MODEL 1A-744 ENGINE



RIGHT SIDE PACKARD MODEL 1A-744 ENGINE



CRANKCASE OF PACKARD MODEL 1A-744 ENGINE

REAR VIEW PACKARD MODEL 1A-744 ENGINE

FRONT VIEW PACKARD MODEL 1A-744 ENGINE

A small threaded plug drains the front end of the lower case. Two breathers are provided, one at the front of the engine in the vee, and the other at the rear of the lower case. A circular plate covers an opening for a starter installation at the rear, in line with the crankshaft. Two gas passages, one on either side of the center crankshft bearing in each case, lead vertically from the underneath carburetor to the intake header extension.

Crankshaft—The crankshaft is a drop forging machined all over. The journals are bored out for lightness and serve as oil passages, there being connecting holes drilled through the webs. The holes in the journals are plugged at either end with steel plugs, which seat on copper asbestos gaskets and are held together by thru-bolts and nuts. A bevel gear fits over splines on the rear end, and is positioned longitudinally by a bronze end plate, which bolts to the crankcase and bears against the ground face of the bevel gear. A double row ball bearing assembly fits over the front end of the crankshaft, and is designed to take thrust in either direction.

Propeller Hub—The propeller hub is made in two pieces, the shank being integral with the rear flange. On the interior, the shank is tapered and keyed to fit on the crankshaft taper. It is counter-bored, for some distance at the center, to insure a better fit. The front flange fits over splines on the shank. A coarse thread and fine thread differential assembly of two nuts holds the propeller hub on the crankshaft, and facilitates removal.

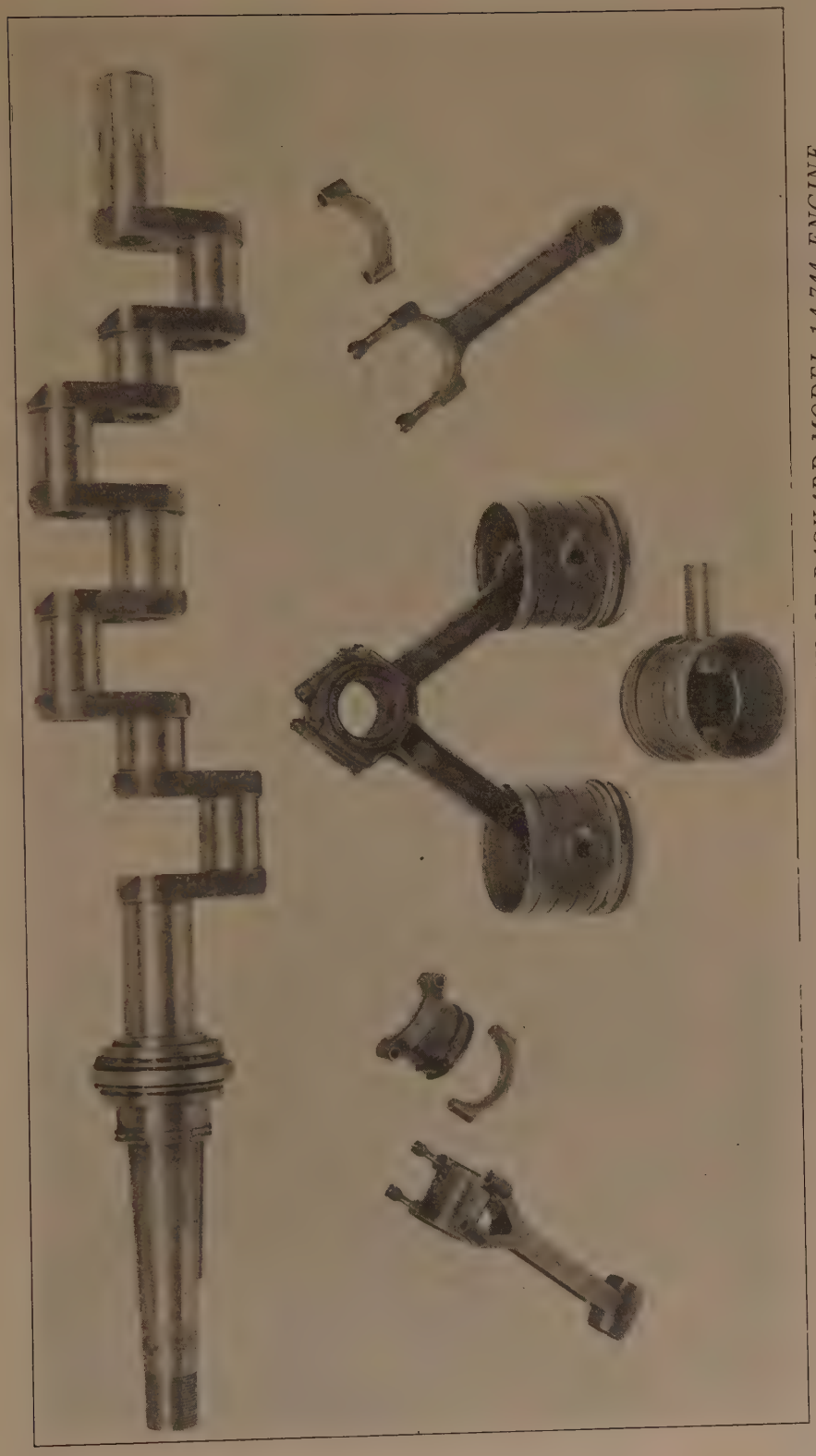
Connecting Rods—The connecting rods are of the straddle type, in which the steel surface of the plain rod bearing acts directly on the back of the bronze bushing in the forked rod. The bronze bushing is babbitt lined and is split along the center. It is clamped in the forked rod by two bearing caps and is doweled in position. The back has collar flanges to limit the end play of the plain rod. Both rods have bronze wrist pin bushings pressed into the small end.

Pistons—The pistons are ribless, and are cast by the permanent mould process, of an aluminum alloy. Three concentric cast iron rings are used. The piston pins are hollow steel tubes of the floating type. They are a free fit in the piston, and are located by aluminum end plugs.

Cylinders—The cylinders are built-up steel forgings, a section of which is shown in Fig. 1. The combustion chamber is a separate forging, butt welded to the barrel. Both valve cages are welded in position, and are recessed into the valve guides to permit better cooling. Cast iron valve guides are pressed into place. The water jackets consist of two sheet iron stampings welded together. Each cylinder is fastened to the crankcase by ten studs and nuts.

Camshaft and Other Drives—The gear train is shown diagrammatically in Fig. 2. The Upper inclined driveshafts of the valve gear connect with the lower drive through a screw driver joint, making it possible to remove the camshafts without disturbing the lower gears. The vertical shaft at the center, which drives the generator, distributors, and camshaft driveshafts, is in three units, the upper two of which bolt into one assembly. This assembly fits through a screw driver joint, over the shaft of the lower unit, the bearing of which bolts to the crankcase.

Valve Gear and Valves—A single camshaft on each bank of cylinders is supported by five split aluminum bushings in an aluminum alloy housing, which fastens to the cylinder heads by means of two studs screwed into bosses on each cylinder. The cams are forged integral with the shaft, and actuate the valves through rocker levers. The contact between the rocker lever and the cam surface is through a roller mounted on a pin. The striking end of the rocker lever is a removable tappet, the effective length of which is adjusted by the insertion of



CRANKSHAFT, CONNECTING RODS AND PISTONS OF PACKARD MODEL 1A-744 ENGINE

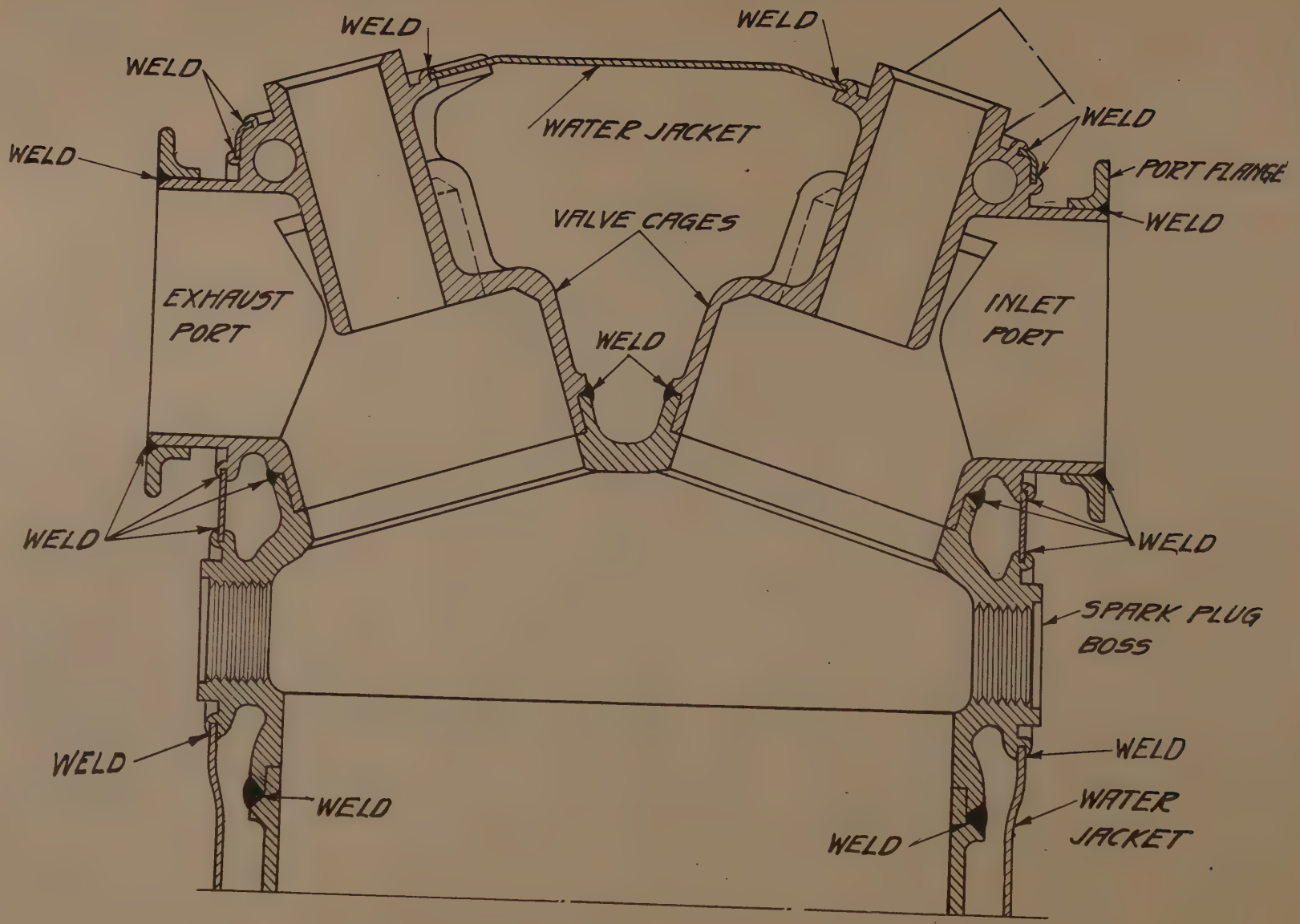

PACKARD MODEL 1A-744 AVIATION ENGINE.
WELD
WELD
WELD
WELD
WELD
WATER JACKET
PORT FLANGE
WELD
VALVE CAGES
EXHAUST PORT
INLET PORT
WELD
WELD
WELD
SPARK PLUG BOSS
WELD
WELD
WELD
WATER JACKET

FIG. 1

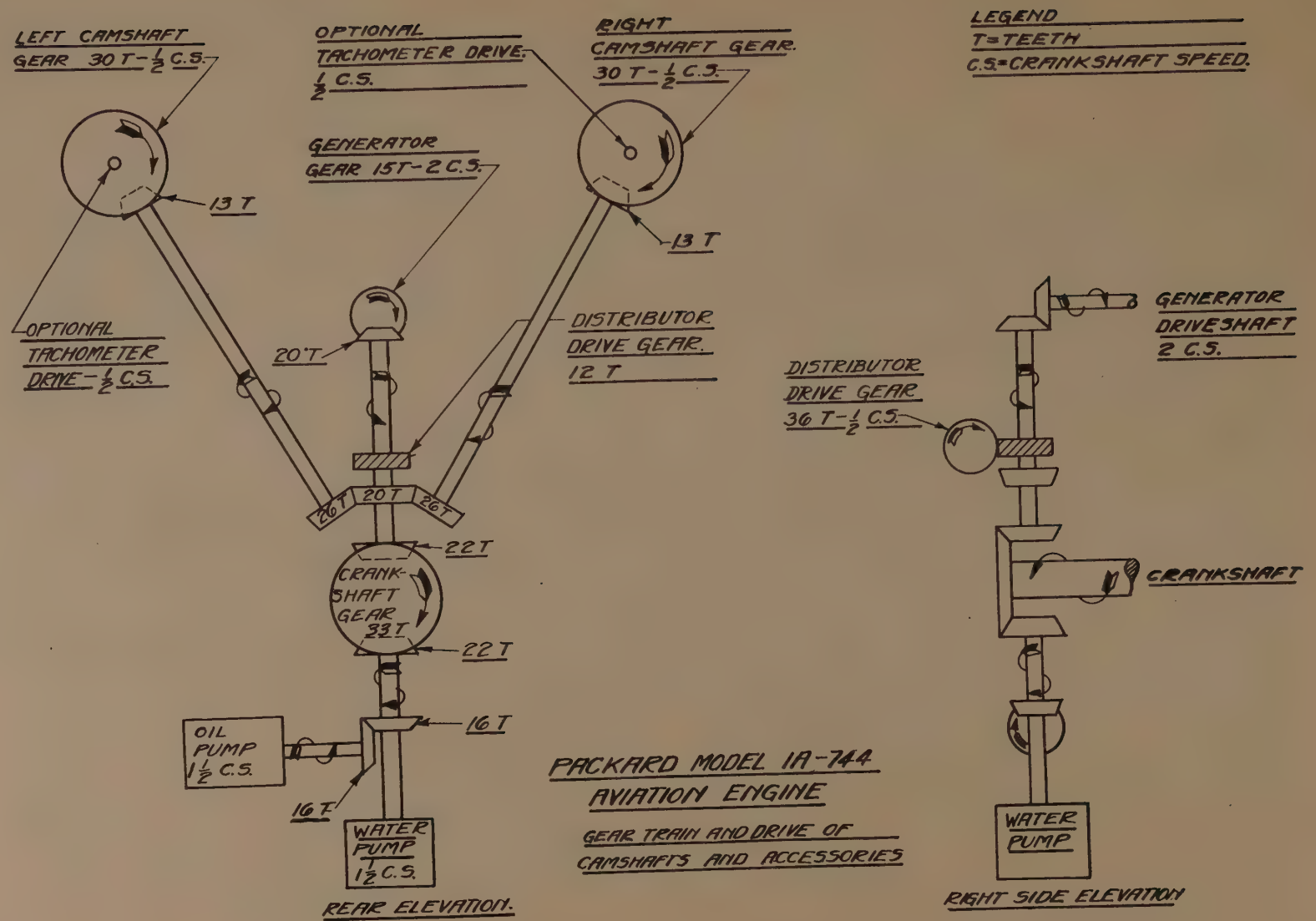
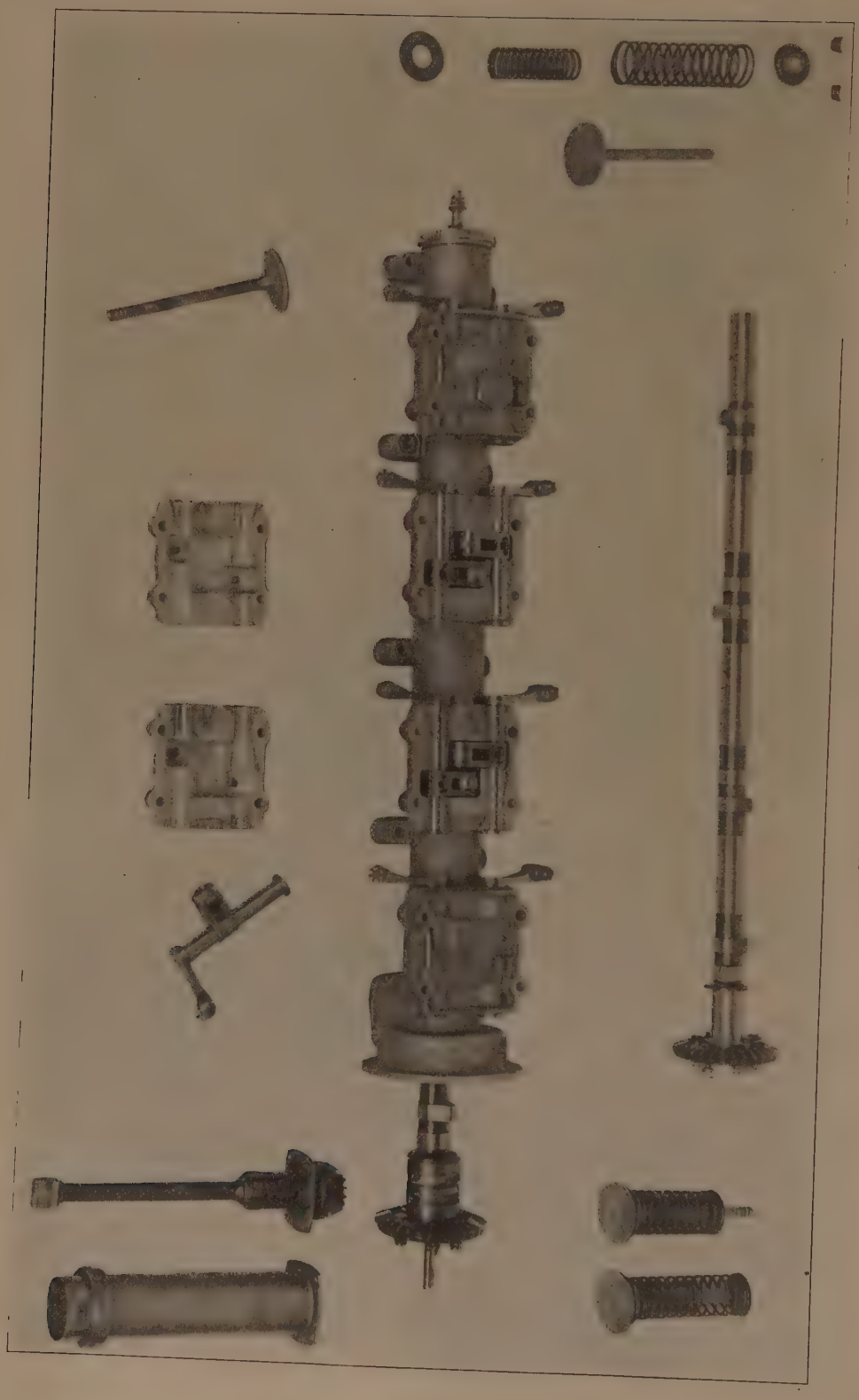
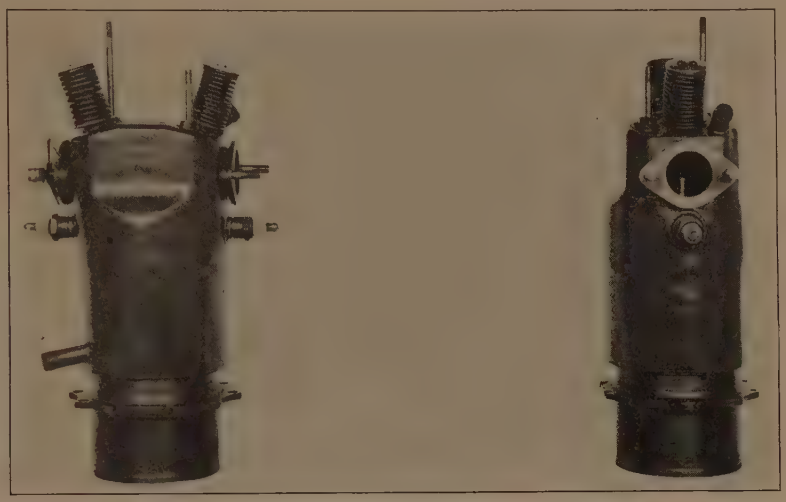

LEFT CAMSHAFT GEAR 30 T - ½ C.S.
OPTIONAL TACHOMETER DRIVE. ½ C.S.
RIGHT CAMSHAFT GEAR. 30 T - ½ C.S.
LEGEND
T = TEETH
C.S. = CRANKSHAFT SPEED.
GENERATOR GEAR 15T - 2 C.S.
13 T
13 T
OPTIONAL TACHOMETER DRIVE - ½ C.S.
20 T
DISTRIBUTOR DRIVE GEAR. 12 T
GENERATOR DRIVESHAFT 2 C.S.
DISTRIBUTOR DRIVE GEAR 36 T - ½ C.S.
20 T
20 T
26 T
22 T
CRANK-SHAFT GEAR 33 T
22 T
CRANKSHAFT
OIL PUMP 1½ C.S.
16 T
16 T
WATER PUMP 1½ C.S.
WATER PUMP
REAR ELEVATION.
PACKARD MODEL 1A-744 AVIATION ENGINE
GEAR TRAIN AND DRIVE OF CAMSHAFTS AND ACCESSORIES
RIGHT SIDE ELEVATION

FIG. 2

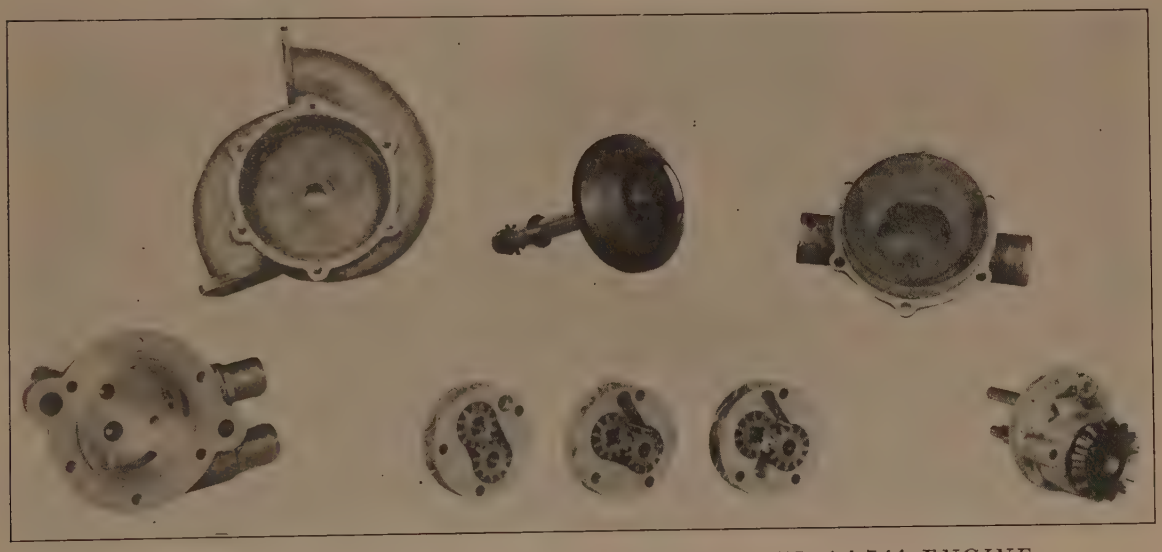


VALVE GEAR AND VALVES

shims beneath the tappet head. Fine adjustments in timing are made by rotating the camshaft gear with respect to the camshaft and the bevel driver, by means of a differential arrangement of drilled holes in the camshaft flange and gear web. An extension fastens to the camshaft gear, which serves to drive the tachometer shaft. The valves are of the conventional mushroom design, the diameter of the stem being slightly reduced just above the valve head. There are two springs per valve, which are held between collars by a split ring key.

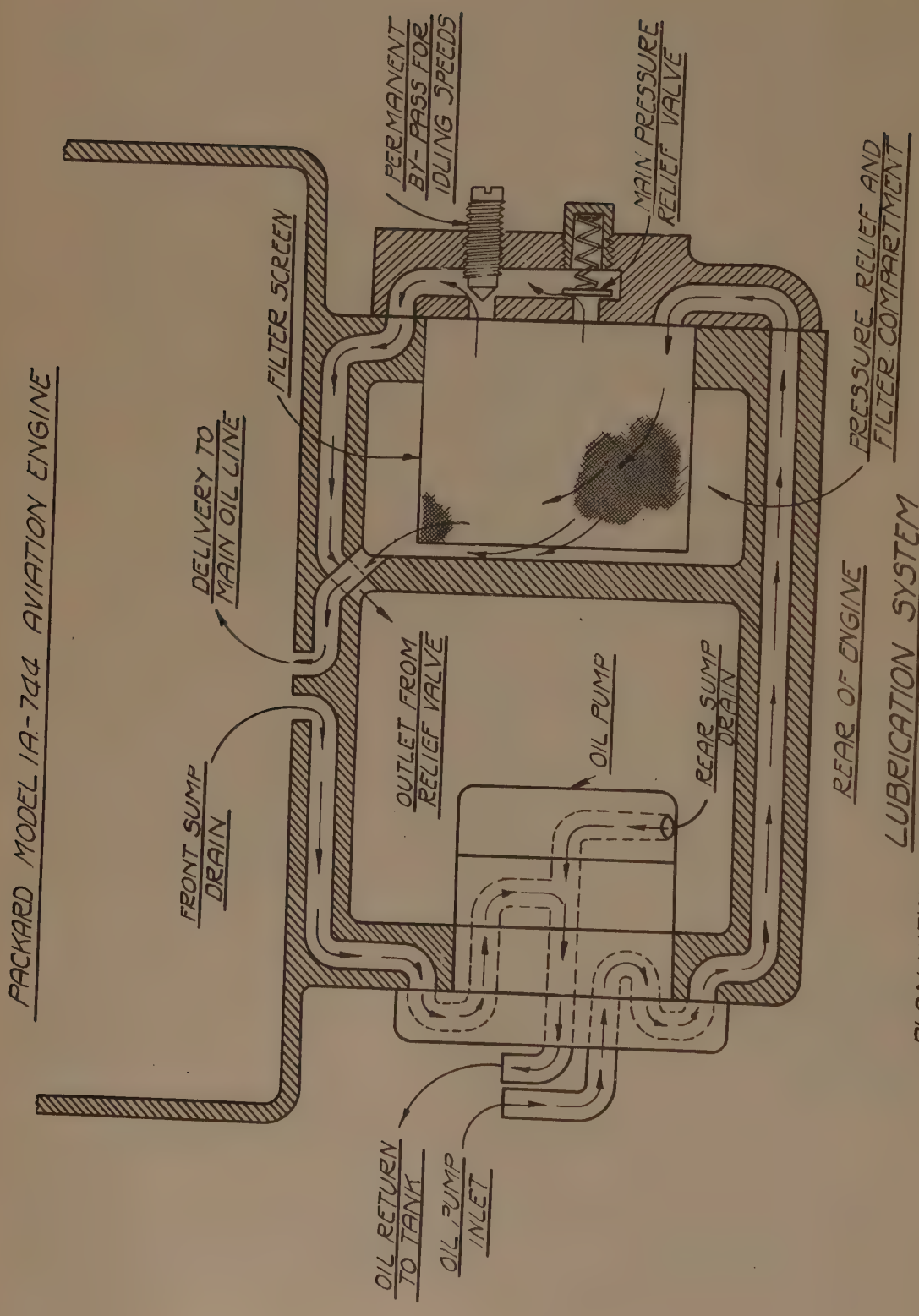


CYLINDERS OF PACKARD MODEL 1A-744 ENGINE



WATER AND OIL PUMPS OF PACKARD MODEL 1A-744 ENGINE

Lubrication—The dry sump system of lubrication is used, which is illustrated diagrammatically in Fig. 3. A three compartment gear pump fits into the rear sump of the crankcase. It contains one pressure delivery pump, and two scavenging pumps, which scavenge the front and rear sumps respectively, delivering in parallel into one outlet. The delivery from the pressure pump is through a removable filter screen into the pressure relief assembly compartment on the right side, and rear of the lower crankcase. The delivery into the screen is on the same



LUBRICATION SYSTEM
PLAN VIEW OF CRANKCASE SUMP SECTION

FIG. 3

side as the pressure relief valve, so that the by-pass valves do not receive strained oil. A spring pressure relief valve is used, the tension of which can be adjusted from the outside without disturbing the assembly. For pressure adjustment at low speeds, there is a constant relief back into the sump past an externally adjustable needle valve. The oil is carried from the screen compartment to the crankshaft bearings through a steel manifold and ducts cast in the bearing webs of the lower half of the crankcase. It is then picked up from the bearings by holes in the crankshaft journals, and passed into the bores of the crank pins. The connecting rod bearings are lubricated by the delivery from the crank pin bores through feed holes on the trailing side of the crank pins. The cylinders, pistons and piston pins are lubricated by spray from the connecting rod bearings. A pocket cast in the front end of the upper crankcase collects oil spray and delivers it to the thrust bearing assembly. A duct in the lower case returns surplus oil from the thrust bearing to the sump. A by-pass around the front main bearing delivers oil to the camshaft housings. The oil enters the bore of the camshafts and is delivered through holes in the journals to the camshaft bearings. The seepage from the bearings lubricates the cams, which in turn throw oil against the housing caps. These carry small brass pegs that collect the oil spray, dripping it down into pockets in the hollow rocker lever spindles. The rocker lever spindles have feed holes, which distribute the oil along their bearing surface. All the oil in the camshaft housings eventually drains out at the rear end through the driveshaft housings back into the crankcase sump. A single lead from the connection at the front end of the engine delivers oil to the generator drive housing, and through a by-pass, to the pressure gage. No drain into the crankcase sump for oil around the bearing in the generator drive shaft housing is provided, although considerable oil seepage from the lead into this space is encountered.

Cooling System—A centrifugal type of water pump is used to maintain the water circulation. A bronze impeller with six shrouded curved vanes is fastened to a steel shaft rotating in two stuffing boxes. These contain graphited packing, the wear on which is designed to be automatically taken up by a spring and bronze bushing. The supply to the engine is through two outlets and through two water manifolds, connecting with the extension on the lower part of each cylinder by means of rubber hose and wire clamps. The outlet from each cylinder is to the water jackets on the intake headers, an outlet from each of which is made to the radiator system.

Carburetor—A Zenith type carburetor of the double venturi type, developed by the Packard Company, is used. This fastens to the underside of the lower crankcase half. The intake gases pass up through passages in the crankcase to an extension, which connects the intake headers and the crankcase. The headers are water jacketed along their tops, and are of the straight gallery type, each header feeding four cylinders. A section of the carburetor is shown in Fig. 4. A removable filter screen is incorporated in the carburetor, through which the gasoline enters the float chamber. This contains the usual metal float, actuating a needle valve to maintain a constant gasoline level. From the float chamber the gasoline passes through two metering jets into two wells. The first, or main emulsion well, is under the depression from the venturi nozzle, which draws the gasoline through the jet. The second, or compensating well, is maintained at atmospheric pressure by an air bleed, consequently the gasoline flow through the compensating jet is by gravity only. The two wells communicate by means of two passages. The delivery to the venturi nozzle is from the main emulsion well only.

In operation, the flow through the main metering jet increases more rapidly than the engine speed, with the result that if this jet alone were depended upon, the mixture richness would increase with the speed. To neutralize this effect, the gravity or compensating jet is employed in connection with the main jet, which is made too lean to run the engine alone. The flow through the compensating jet is constant at all speeds, being governed only by the pressure head in the float chamber and the size of the metering orifice. Thus, in proportion to the total delivery to the noz-

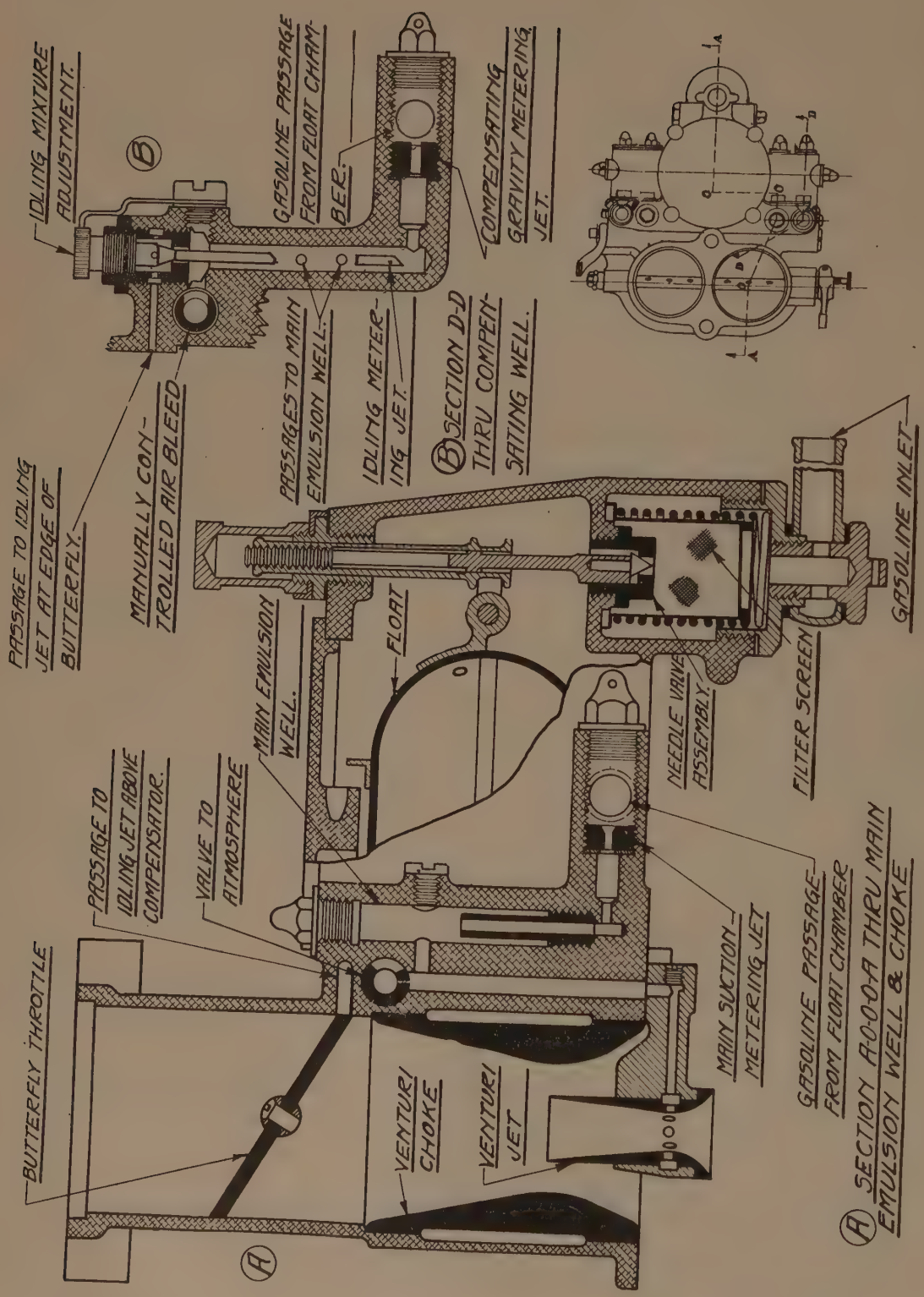

IDLING MIXTURE ADJUSTMENT.
GASOLINE PASSAGE FROM FLOAT CHAMBER.
COMPENSATING GRAVITY METERING JET.
PASSAGE TO IDLING JET AT EDGE OF BUTTERFLY.
MANUALLY CONTROLLED AIR BLEED
PASSAGES TO MAIN EMULSION WELL.
IDLING METERING JET.
B SECTION D-D THRU COMPENSATING WELL.
MAIN EMULSION WELL.
FLOAT
NEEDLE VALVE ASSEMBLY.
FILTER SCREEN
GASOLINE INLET
PASSAGE TO IDLING JET ABOVE COMPENSATOR.
VALVE TO ATMOSPHERE
BUTTERFLY THROTTLE
VENTURI CHOKE
VENTURI JET
MAIN SUCTION METERING JET
GASOLINE PASSAGE FROM FLOAT CHAMBER
A SECTION A-O-O-A THRU MAIN EMULSION WELL & CHOKE

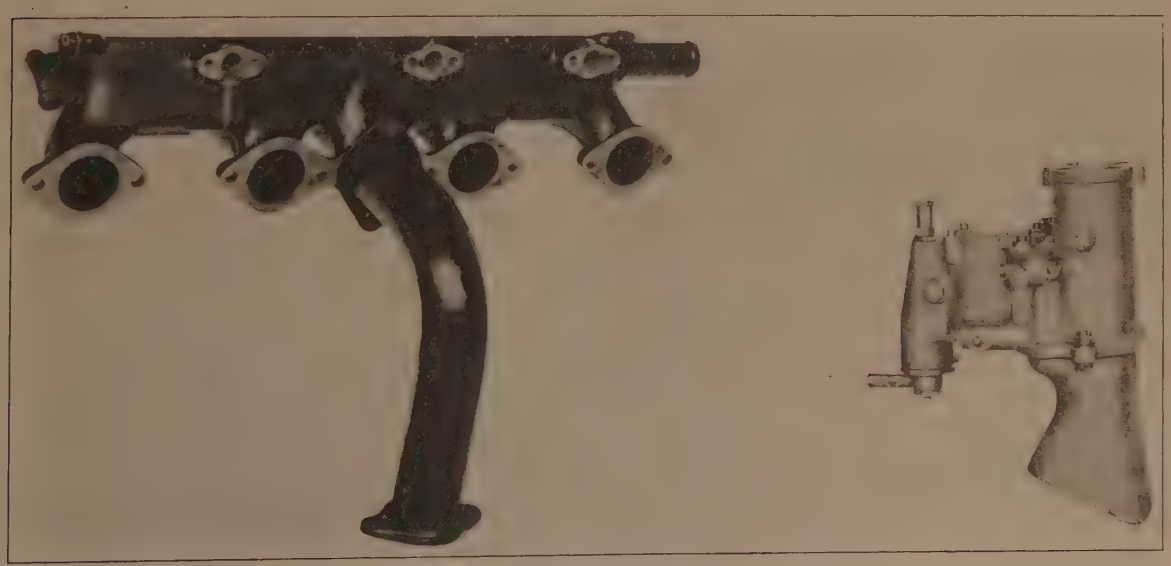
FIG. 4

zle the constant flow through the compensating jet at increasing speeds, decreases approximately as the flow through the main jet increases. The drain on the compensating well at normal speeds is considerably in excess of the gasoline delivery. A considerable amount of air is therefore drawn in with the gasoline into the emulsion well, where a mixture of the two occurs as they pass over to the delivery nozzle. The mixture richness can be adjusted by changing the removable metering jets. As will be noted in Fig. 4, the highest point of the main gasoline passage to the nozzle is above the float level. This effectually prevents gasoline running out of the jet by gravity, even at steep angles of the airplane. A small drill hole in the mixture control valve body prevents syphon action through the main passage, even when the mixture control valve is closed.

For slow speed running, the vertical idling tube receives gasoline and a quantity of air from the compensating well. The amount of air, and therefore the mixture richness, is controlled by raising or lowering the conical screw which forms the upper end of the idling tube. For this purpose the screw is threaded into the carburetor body against a conical seat over the compensating well. The gasoline enters through the metering jet, and the air around it past the valve seat. At the top of the jet, the two are emulsified and delivered through a passage to the edge of the butterfly.

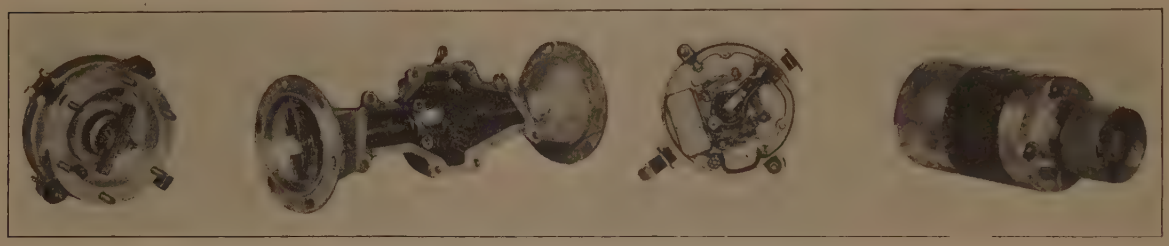
The air flow through the carburetor is unimpeded by any sharp turns or obstructions. The air enters the carburetor through a short horn with its leading edge in the slipstream cut away at a 45° angle. It passes up through the large venturi shaped choke, at the throat of which is placed the second venturi. This communicates with the main gas passageway and acts as the gasoline nozzle, more thorough atomization occurring because of the high depression at the venturi throat. A butterfly throttle is placed directly above the large venturi, past which the gasoline vapor is carried into the manifolds. A further adjustment of the mixture can be obtained by changing the large venturi, using throat diameters of various sizes, to create varying depressions at the venturi nozzle. The idling speed, within limited range, can be controlled by the exterior butterfly stop screws. These control the size of the opening at the edge of the butterfly in the closed position and, consequently, the depression at the idling jet delivery orifice.

The mixture richness at altitudes is controlled by a manually operated rotary valve which admits air to the main gas passage between the main jets and the delivering venturi jet. A by-pass around this valve forms the main air bleed to the compensating well. The air enters the hollow center of the valve through two drilled passages leading from the air scoop.



CARBURETOR AND INTAKE MANIFOLD OF PACKARD MODEL 1A-744 ENGINE

Ignition—The Delco battery-generator ignition system is used. The main current supply is from a generator clamped by a strap band in the vee of the engine, and driven through a flexible coupling. A ratchet device is incorporated in the coupling which permits forward rotation only. The auxiliary supply is from a storage battery, which is used for starting. Constant voltage is maintained by a voltage regulator, which is a magnetic device usually attached to the control switch, and which automatically cuts in the proper resistance on the field of the generator. Two distributors are used, each firing one plug in each cylinder of the engine. The distributor covers contain the high tension coils, and are removable. Each distributor has two main breakers in parallel and a third auxiliary breaker to prevent the engine running backwards. When the engine is rotated backwards, the auxiliary breaker opens first, throwing a resistance coil, with which it is in parallel, into the main line. This lowers the potential to the point where a spark cannot occur. With the forward rotation, the auxiliary breaker opens last, cutting in the resistance after the main breakers have opened. The distributor heads are fixed, and adjustment of the spark advance is made by rotating the distributor cams with respect to the drive shaft by means of a lever, which slides the spiral distributor drive gear on its shaft. The distributor drive assembly is removable as a unit, and consists of an aluminum housing, which carries the distributor cross shaft and its bearings. One distributor bolts to each end of the housing.



DISTRIBUTOR, DISTRIBUTOR DRIVE AND GENERATOR

Auxiliaries—A tachometer drive is provided from the rear end of either camshaft. Provision is made for installing a Bijur electric starter to drive through an internal spline at the rear end of the crankshaft.

Airplane Mounting—This engine may be used either as a tractor or a pusher. The mounting requires five through-bolts on each side. Any standard form of radiator and exhaust manifold may be used. The following connections are necessary between the engine and the airplane:

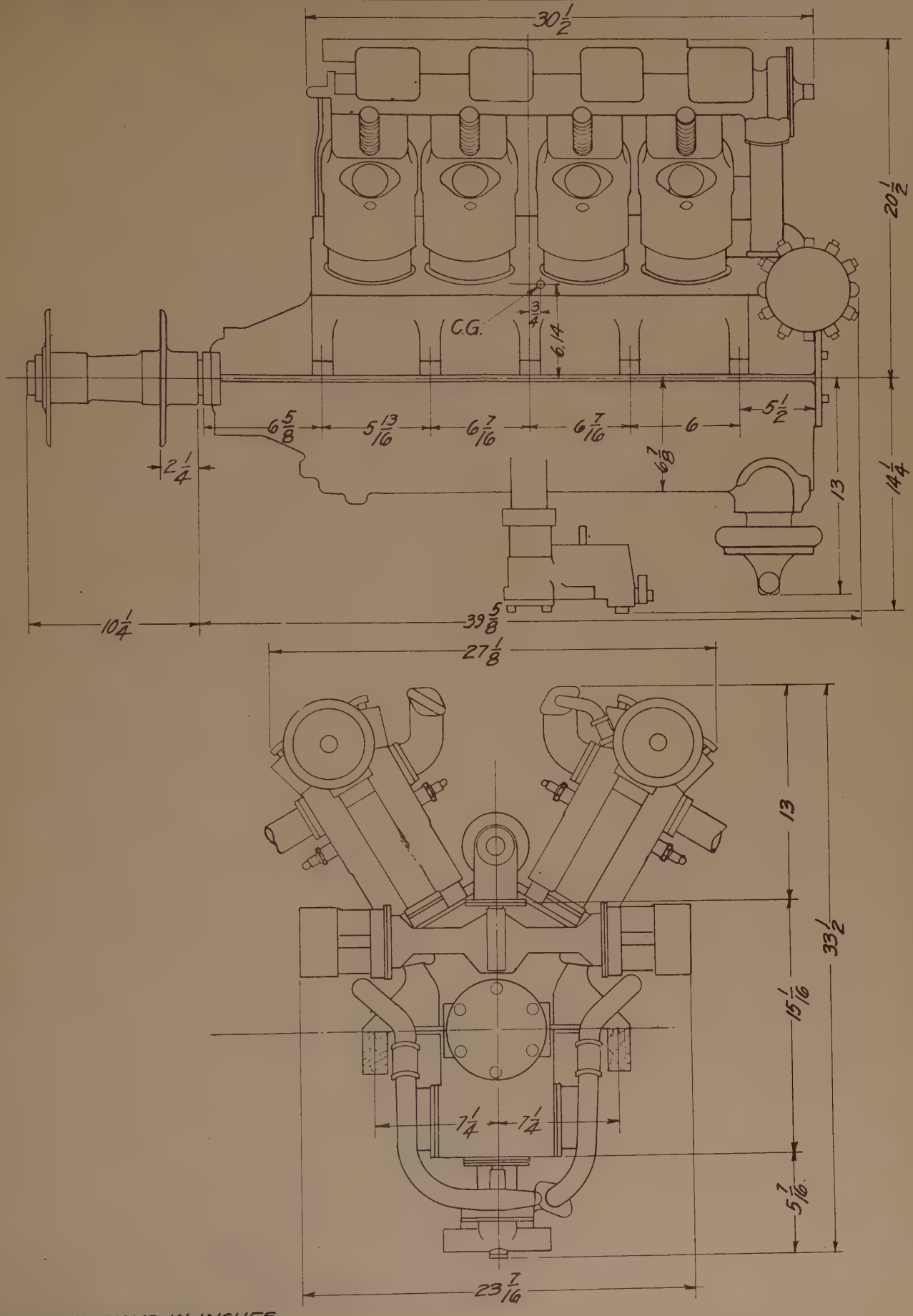
Controls—Two connections to the carburetor must be made; one each for the throttle and mixture control. One connection for the spark control is necessary from the cockpit to a lever at the rear end of the upper crankcase half.

Tachometer—A connection is provided at the rear end of each camshaft housing, either, or both, of which serve as tachometer drives.

Cooling System—The cooling system is connected to the radiator to form a closed circuit. There are four connections to be made; two inlets to the water pump at the rear end of the lower crankcase, and two outlets from each intake header water jacket.

Lubrication System—There are three connections to be made for this system; one from the tank to the inlet of the pressure pump, one from the outlet of the scavenging pumps to the tank, and one from the connection at the generator drive to the pressure gage. The inlets and outlets of the pump form a closed circuit with the oil tank.

PACKARD MODEL 1A-744 AVIATION ENGINE INSTALLATION DRW'G.



ALL DIMENSIONS IN INCHES.

Fuel System—The carburetor has to be connected with the fuel supply line.

Ignition System—The ignition system requires five connections; two connections lead from the generator to the switch and voltage regulator, one connection from the battery to the switch, and one connection from the switch to each of the distributors. The storage battery must be grounded on the switch or at some other convenient point.

DIMENSIONS OF PACKARD MODEL 1A-744 AVIATION ENGINE AND PARTS

General:

Number of cylinders	8
Arrangement	Two rows of four, with 60° included angle
Bore	4.750 in.
Stroke	5.250 in.
Cycle	Four-stroke
Cooling	Water
Rotation of propeller	Counter-clockwise, facing propeller
Total piston displacement	744.24 cu. in.
Approximate head area	3.74 sq. ft.
Firing order	1L-4R-3L-2R-4L-1R-2L-3R
Method of numbering cylinders	From the rear, each block starting with No. 1

Crankcase:

Material	Aluminum alloy
Distance between centers of cylinders	1—2, 3—4 6.000 in.
	2—3 6.875 in.
Diameter of main bearing studs on shank	7/16 in.
Main crankshaft bearings—	
Material	Babbitt-lined bronze

No.	Clearance to shaft		Length	Projected area
	Diametral	End		
1, 2, 4	0.003 in.	0.125 in.	1.625 in.	3.86 sq. in.
3	0.003 in.	0.125 in	2.500 in.	5.94 sq. in.
5	0.003 in.	——	4.313 in.	10.26 sq. in.

Crankshaft:

Material	Steel forging
Main journals—	

No.	Bore Diameter	Outside diameter	Length
1	1.000 in.	2.375 in.	1.625 in.
2	1.000 in.	2.375 in.	1.750 in.
3	1.000 in.	2.375 in.	2.625 in.
4	1.000 in.	2.375 in.	1.750 in.
5	1.000 in.	2.375 in.	4.438 in.

Crankpins—

No.	Bore diameter	Outside diameter	Length
1	1.000 in.	2.125 in.	2.500 in.
2	1.000 in.	2.125 in.	2.500 in.
3	1.000 in.	2.125 in.	2.500 in.
4	1.000 in.	2.125 in.	2.500 in.

Thrust bearing—

Type	Double row, ball
Number of balls	17 per row
Diameter of balls	0.500 in.
Diameter of ball circle	3.346 in.
Manufacturer and number	Hess-Bright No. 12048
Length of shaft from front end to first crank cheek	17.125 in.

Propeller Hub:

Material	Steel forging
Bearing surface—	
Front end diameter	1.813 in.
Rear end diameter	2.396 in.
Front to rear length	7.000 in.
Counterbore, length	3.000 in.
Area	26.73 sq. in.
Diameter of hub body	3.125 in.
Distance between flanges—	
Maximum	6.500 in.
Minimum	4.438 in.
Diameter of bolt circle	6.750 in.
Number of bolts	8
Diameter of bolts	0.500 in.

Connecting Rods:

Type	Straddle assembly
Material	S.A.E. steel, No. 6135, drop forged
Section	Channel "I" beam
Plain rod—	
Length, center to center	9.000 in.
Bolts—	
Number	2
Minimum shank diameter	0.437 in.
Thread	7/16-20 (S.A.E.)
Forked rod—	
Length, center to center	9.000 in.
Bolts—	
Number	4
Minimum shank diameter	0.312 in.
Thread	5/16-24 (S.A.E.)
Rod-stroke ratio	1.714:1

Wrist pin bushing—	
Length	2.000 in.
Diameter, inside	1.252 in.
Material	Bronze
Clearance to pin	0.002 in.
Projected area	2.500 sq. in.
Big end bearing, plain—	
Length	1.125 in.
Diameter	2.631 in.
Material	Steel surface
Clearance on forked rod—	
Diametral	0.006 in.
End	0.006 in.
Big end bearing, forked—	
Length	2.492 in.
Material	Bronze
Clearance on crankpin—	
Diametral	0.0025 in.
End	0.008 in.
Projected area on crankpin	5.32 sq. in.

Pistons:

Type	Ribless
Material	Aluminum alloy
Area of head	17.72 sq. in.
Distance from center of pin to top of piston	2.250 in.
Length, overall	4.250 in.
Length of bearing in cylinder	3.094 in.
Clearance in cylinder—	
Top	.037 in.
Bottom	.017 in.
Rings—	
Type	Peened, concentric, 60° diagonal gap
Number per piston	3
Tension	9 lbs.
Width	0.217 in.
Width of gap, ring in cylinder	0.031 in.
Pin—	
Length	4.141 in.
Diameter	1.250 in.
Bore diameters—	
Ends	0.875 in.
Center	0.875 in.
Fixed or moving in piston	Moving
Total length of bearing in piston	2.016 in.

Cylinders:

Number		8
Material—		
Barrel		Steel
Head		Steel
Jacket		Stamped iron
Ports		Steel
Valve guides		Cast iron
Valve seats		Steel
Bore		4.75 in.
Stroke		5.25 in.
Stroke-bore ratio		1.105:1
Piston displacement per cylinder		93.03 cu. in.
Total piston displacement		744.24 cu. in.
Compression volume		23.17 cu. in.
Compression ratio		5.02:1
Per cent compression		24.9
Port openings—	Intake	Exhaust
Number per cylinder	1	1
Diameter	1.750 in.	1.750 in.
Number of studs	2	2
Water connections—	No.	Inside diameter
Inlet	1	0.680 in.
Outlet	1	0.680 in.
Minimum thickness of water space around cylinder barrel		0.156 in.
Hold down studs—		
Number		10
Diameter		0.375 in.
Thread		3/8-24 (S.A.E.)

Camshafts:

Material			Steel, S.A.E. Spec. No. 1020
Diameter—			
Outside			0.984 in.
Bore			0.688 in.
Journals—			
No.		Diameter	Length
1		1.124 in.	1.875 in.
2		0.998 in.	2.781 in.
3		0.998 in.	3.656 in.
4		0.998 in.	2.781 in.
5		0.998 in.	3.188 in.
Bearings—			
No.	Material	Clearance on journals	Length
1	Bronze, babbitt lined	.001 in.	1.875 in.
2	Aluminum alloy	.002 in.	2.500 in.
3	Aluminum alloy	.002 in.	3.375 in.

4	Aluminum alloy	.002 in.	2.500 in.
5	Aluminum alloy	.002 in.	3.250 in.

Cams—	Base diameter	Width	Lift
Intake	1.105 in.	0.500 in.	0.302 in.
Exhaust	1.105 in.	0.500 in.	0.260 in.

Valves:

Inlet valves—

Number per cylinder	1
Inside diameter of seat	2.000 in.
Lift	7/16 in.
Angle of seat	30°
Total area of opening	2.61 sq. in.
Stem diameter	0.435 in.
Tappet clearance	0.013—0.016 in.

Exhaust valves—

Number per cylinder	1
Inside diameter of seat	2.000 in.
Lift	3/8 in.
Angle of seat	30°
Total area of opening	2.20 sq. in.
Stem diameter	0.435 in.
Tappet clearance	0.019—0.021 in.

Valve springs—

Number per valve	2
Tension inlet, both springs—	
Valve open	63.5 lbs.
Valve closed	47.5 lbs.
Tension exhaust, both springs—	
Valve open	81.5 lbs.
Valve closed	61.5 lbs.
Internal spring tension—	
Valves closed	24 lbs.
valves open	35 lbs.

Valve timing—

Inlet—	Actual average	Designed
Opens	12½°	10° after top center
Closes	49¼°	45° after bottom center
Exhaust—		
Opens	46°	48° before bottom center
Closes	12°	8° after top center

Drive Gears:

Gear	Type	Pitch Diameter	Number of teeth	Face Width	Shaft Diameter
Crankshaft	Bevel	4.125 in.	33	0.500 in.	———
Vertical shaft: to crankshaft	Bevel	2.750 in.	22	0.500 in.	1.124 in.
Vertical shaft: to camshaft driveshaft	Bevel	2.000 in.	20	0.625 in.	1.375 in.
Camshaft driveshaft: lower	Bevel	2.600 in.	26	0.625 in.	0.999 in.
Camshaft driveshaft: upper	Bevel	1.625 in.	13	0.625 in.	0.625 in.
Camshaft	Bevel	3.750 in.	30	0.625 in.	———
Vertical shaft: to distributor drive	Helical	2.211 in.	12	0.625 in.	1.375 in.
Distributor drive	Helical	2.789 in.	36	0.625 in.	0.434 in.
Vertical shaft: to generator	Bevel	2.000 in.	20	0.4375 in.	0.999 in.
Generator	Bevel	1.500 in.	15	0.4375 in.	0.500 in.
Water pump driver: to crankshaft	Bevel	2.750 in.	22	0.500 in.	0.999 in.
Water pump driver: to oil pump	Bevel	2.000 in.	16	0.3125 in.	0.999 in.
Oil pump	Bevel	2.000 in.	16	0.3125 in.	0.370 in.

Oil Pump:

Type	Pressure Gear	Scavenging Gear
Number	1	2
Number of gears	2 in each	2 in each
Pitch diameter of gears	1.000	1.000
Number of teeth	12	12
Face width	0.622 in.	0.747 in.

Water Pumps

Material—Housing	Aluminum alloy
Impeller	Bronze
Type	Enclosed, curved vane, centrifugal
Diameter of impeller	3.875 in.
Number of vanes	6
Width of vanes at tip	0.250 in.
Shaft diameter	0.623 in.
Inlets—	
Number	2
Inside diameter	1.156 in.
Outlets—	
Number	2
Inside diameter	1.125 in.

Water Connections to Engine:

	Number	Inside diameter	Outside diameter
Inlet	2	1.156 in.	1.406 in.
Outlet	2	1.156 in.	1.234 in.

Carburetor:	
Number	1
Material of body	Aluminum alloy
Name	Packard
Type	Double venturi
Diameter at the flange	2.000 in.
Chokes, diameter	1.34 in.
Jets, material	Brass
Metering jets, diameter—	
Main	No. 49 drill size
Compensating	No. 50 drill size
Idling well	No. 47 drill size
Type of mixture control	Air bleed to main gasoline passage between float chamber jets.
Ignition:	
Type	Battery, generator, distributor
Manufactured by	Dayton Engineering Laboratories Company
Model	Packard-Delco
Maximum spark advance	45° before top center
Maximum spark retard	10° after top center
Generator—	
Type	Shunt wound
Voltage	12 volts
Speed	2 crankshaft speed
Number of distributors	2
Breaker gaps, width of	0.015 in.
Storage battery—	
Number	1 six cell
Voltage	12 volts
Spark plugs—	
Name	A. C.
Number per cylinder	2
Location	Side of head
Size of thread	18 mm. diameter—1.5 mm. pitch (S.A.E. metric)
Insulator	Porcelain
Gap	.015 in.
Auxiliaries:	
Tachometer drive connection—	
Location	Rear of camshaft gear
Speed	1/2 crankshaft speed
Threads	7/8-18 U. S. Standard
Reciprocating and Centrifugal Weights:	
Piston, complete, with rings and pin	3.9 lbs.
Upper end connecting rod	1.1 lbs.

Lower end forked connecting rod	3.3 lbs.
Lower end plain connecting rod	1.4 lbs.
Total weights of connecting rods complete—	
Plain	2.5 lbs.
Forked	4.4 lbs.
Total connecting rod assembly	6.9 lbs.
Valve and upper spring retainers	0.56 lbs.
Valve springs	0.37 lbs.

Loads from Maximum Explosion Pressure:

Assumed maximum explosion pressure	465 lbs. per sq. in.
Total load on piston head	8,240 lbs.
Load on wrist pin rod bearing	3,290 lbs. per sq.in.
Load on crank pin	1,548 lbs. per sq. in.
Load on main bearings—	
Bearing position	Load, lbs. per sq. in.
1, 2 and 4	1,066
3	694
5	402

WEIGHTS OF PACKARD MODEL 1A-744 AVIATION ENGINE AND PARTS

		Weight pounds	Per cent of total
Cylinder group, including 8 cylinder assemblies complete with valves and springs each averaging about 15.6 lbs. Total..		124.6	23.0
Crankcase group, complete with bearings, studs, nuts and breathers, including—			
1 upper half	60.3 lbs.		
1 lower half	48.3 lbs.		
Total		108.6	20.1
Crankshaft group, complete with gear and end spacer, thrust bearing and oil plugs		64.8	12.0
Camshaft group, including—			
2 Camshafts, complete with gears and bearings	14.4 lbs.		
2 camshaft housings, complete with rocker arms, nuts, bolts and caps	35.1 lbs.		
Total		49.5	9.1
Ignition group, including—			
1 generator	12.1 lbs.		
1 storage battery	10.5 lbs.		
1 set of wires, header and 2 distributor covers	10.1 lbs.		
2 distributor heads	4.9 lbs.		

16 spark plugs	2.9 lbs.		
1 switch and voltage regulator	2.1 lbs.		
Total		42.6	7.9
Piston group, including 8 piston assemblies complete with rings, pins and pin retainers, each averaging about 3.9 lbs.			
Total		31.1	5.7
Connecting rod group, including—			
4 forked rod assemblies each averaging 4.4 lbs.	17.6 lbs.		
4 plain rod assemblies each averaging 2.5 lbs.	10.0 lbs.		
Total		27.6	5.1
Carburetor and intake group, including—			
2 intake headers and extensions	17.3 lbs.		
1 carburetor assembly	8.7 lbs.		
Total		26.0	4.8
Driving gear group, including—			
1 generator drive and housing	7.3 lbs.		
2 inclined shafts and housings	7.2 lbs.		
2 camshaft driveshafts, lower	5.3 lbs.		
1 distributor drive	4.5 lbs.		
Total		24.3	4.5
Propeller hub assembly, complete		18.6	3.4
Cooling system group, including—			
Water manifolds and connections	5.8 lbs.		
Water pump assembly	4.7 lbs.		
Total		10.5	1.9
Lubrication group, including—			
1 oil pump assembly	4.2 lbs.		
1 oil relief valve assembly	1.2 lbs.		
Total		5.4	1.0
Miscellaneous items, including cotter pins, nuts, bolts, small tubing, etc.		8.2	1.5
Total weight of engine without auxiliaries		541.8	100.0
Weight of water in engine		25.7	

Method of Test

For a detailed description of the methods used in making the following tests and in calculating the results, Power Plants Report No. 69, Serial No. 739, should be consulted. As described in the above mentioned report, all runs were made with the engine connected to an electric cradle dynamometer, and the controls set to give the best possible performance at each speed.

The following runs were made:

2 full power runs
1 friction horsepower and compression pressure run.
2 propeller load runs
1 one hour fuel and oil consumption run
1 water circulation run through the engine
1 oil circulation run through the engine
1 water pump capacity run with free outlet
1 oil pump capacity run with free outlet.

Results of Test

The test results which appear in this report were obtained from manufacturer's engine No. 2. It must be borne in mind that in laboratory tests it is possible to operate an engine under more favorable conditions than in actual service. The engine under consideration, therefore, when installed in an airplane, and run by the average pilot, will not develop the power nor have the fuel economy which is recorded in the tables and curves in this report. It will be noted that the air temperature during the various runs averaged about 45° F. and therefore the power results are perhaps a little higher than would have been obtained at the standard air temperature of 60° F. The power results are not corrected for temperature as no reliable method is at present available.

Observations During Test

During the preliminary running made to bring the engine up to its rated power, trouble was encountered in maintaining a constant power at a given speed. The power drop, which was not very large, was finally traced to a defective float assembly in the carburetor. Due probably to a bent actuating crank, the float interferred with the float chamber cover, leaving the needle valve slightly open at all times, and causing the carburetor to flood. When this was repaired, the trouble disappeared. The engine appeared to run with considerable vibration, but under laboratory conditions it is impossible to obtain accurate observations on vibration due to the rigid mounting. Reliable conclusions on this point, therefore, cannot be made.

Considerable oil leakage was observed at the bases of the generator and camshaft driveshaft housings, at the rocker levers of the camshaft assembly, and from the main breather at the front of the engine. Large quantities of oil were lost through the breather at the rear sump of the lower case. In order to obtain data as to the actual oil consumption, it became necessary, therefore, to remove the rear breather and close its crankcase opening. This change, however, had previously been decided upon at the factory and adopted as standard shortly after shipment of the engine to be tested. The packing of the water pump leaked throughout the test.

Full Power Runs

FIRST RUN

R.P.M.	Actual		Corrected			Temperature °F.				Oil Pressure sq. in.	Air Temp. °F.	Man. Vac. In. Hg.	Carb. Vac. In. Hg.	Gas. Cons.	
						Water		Oil							
	Brake Load Lbs.	B.H.P.	Torque Lbs./ Ft.	H.P.	B.M.E P. Lbs./ sq. in.	In	Out	In	Out					Sec. for 3 Lbs.	Lbs. Hp. Hr.
1190	362	143.5	647	146.3	131.2	142	156	100	107	40	50	1.1	0.7	141.0	.534
1310	361	157.6	645	160.7	130.7	147	162	102	110	42		1.1	0.8		
1420	347	164.2	620	167.5	125.6	146	161	106	112	42	51	1.1	0.8	139.8	.471
1510	340	171.2	607	174.5	123.1	145	159	109	116	42		1.15	0.85		
1600	333	177.5	595	181.0	120.6	146	159	112	120	42	51	1.2	0.95	129.0	.472
1690	324	182.5	578	186.1	117.2	147	160	115	125	41		1.3	1.0		
1820	311	188.7	555	192.5	112.5	148	160	119	128	41	50	1.35	1.0	123.2	.465
1910	302	192.3	540	196.1	109.5	146	160	123	132	42		1.45	1.1		
2000	291	194.0	519	197.9	105.2	147	160	126	136	42	48	1.6	1.2	119.4	.466

SECOND RUN

1220	365	148.5	654	152.0	132.5	147	160	92	101	35	41	0.95	0.75	138.8	.524
1290	361	155.2	647	158.9	131.1	143	158	95	103	35		1.0	0.8		
1420	342	161.9	612	165.6	124.0	144	160	99	106	36	43	1.1	0.85	137.0	.487
1530	343	174.9	614	179.0	124.5	145	160	102	110	37		1.1	0.75		
1610	333	178.7	597	182.9	121.0	146	159	104	111	38	45	1.15	0.8	127.2	.476
1720	319	182.9	571	187.2	115.6	146	160	108	116	38		1.25	0.95		
1820	312	189.3	559	193.7	113.2	146	160	110	119	37	43	1.4	1.05	120.2	.475
1930	305	196.2	547	200.9	110.9	146	158	112	122	38		1.5	1.1		
2010	291	195.0	521	199.6	105.6	148	160	115	125	38	44	1.6	1.2	115.8	.478

First Run

Length of brake arm..... 21″
Kind of oil used..... U. S. Spec. No. 3501
Specific gravity of gasoline..... 0.708 at 15° C.
Average barometer ..... 29.33 In. Hg.

Second Run

Length of brake arm ..... 21″
Kind of oil used ..... U. S. Spec. No. 3501
Specific gravity of gasoline..... O. 708 at 15° C.
Average barometer ..... 29.23 In. Hg.

Pump Capacity Runs Free—Intake and Discharge

WATER PUMP RUN

Speed, R.P.M.		Drive Torque Lbs./ft.	Drive Horse-power	Flow	
Pump	Engine			Sec. for 200 Lbs.	Gallons per Minute
1800	1200	1.60	0.548	31.2	46.2
2100	1400	1.85	0.740	27.0	53.4
2400	1600	2.20	1.005	24.3	59.3
2700	1800	2.60	1.337	21.3	67.7
3000	2000	2.90	1.656	19.1	75.5

Maximum pressure at 2400 R.P.M.—8.5 lbs. per sq. in.

WATER PRESSURE PUMP RUN

Speed, R.P.M.		Drive Torque Lbs./ft.	Drive Horse-power	Flow	
Pump	Engine			Sec. for 5 Lbs.	Gallons per Minute
1800	1200	1.05	0.360	19.3	2.10
2100	1400	1.10	0.440	16.7	2.43
2400	1600	1.15	0.526	14.9	2.72
2700	1800	1.25	0.642	13.2	3.07
3000	2000	1.30	0.743	12.3	3.30

Maximum pressure at 2400 R.P.M.—over 200 lbs. per sq. in.

OIL SCAVENGING PUMP RUN

Speed, R.P.M.		Drive Torque Lbs./ft.	Drive Horse-power	Flow	
Pump	Engine			Sec. for 5 Lbs.	Gallons per Minute
1800	1200	1.30	0.446	10.4	3.90
2100	1400	1.35	0.540	9.6	4.22
2400	1600	1.45	0.663	8.9	4.56
2700	1800	1.55	0.796	8.4	4.83
3000	2000	1.65	0.943	7.5	5.41

Oil used ..... U. S. A. Spec. No. 3501
Average oil temperature ..... 82° F.
Specific gravity of oil ..... 0.8883 at 82° F.
Weight of oil ..... 7.4 lbs. per gal. at 82° F.

Water Circulation Run

Engine Speed R.P.M.	Water Temperature °F.			Flow Through Engine		
				Measured Flow		Gallons per Minute
	Inlet	Outlet	Tank*	Pounds	Seconds	
1200	157	157	144	192.0	34.6	40.0
1400	165	165	151	182.5	27.8	47.3
1600	160	160	151	180.0	23.8	54.5
1800	164	164	152	153.0	18.0	61.2
2000	159	160	148	143.0	15.4	66.9

*Discharge into measuring tank.

Oil Circulation Run

Engine Speed R.P.M.	Temperatures °F.					Oil Pressure Lbs./ sq. in.	Press. Pump Delivery	
	Water		Oil				Time in seconds for 5 Lbs.	Gallons per Minute**
	In	Out	In	Out	Tank*			
1200	157	157	97	104	100	48	20.0	2.04
1400	165	165	102	108	103	52	17.0	2.40
1600	160	160	96	102	96	55	15.0	2.72
1800	164	164	100	107	100	57	13.6	3.00
2000	159	160	98	105	102	58	12.6	3.24

*Delivery into measuring tank.
**Oil used—U. S. A. Specification No. 3501:
Specific gravity at 100° F.—0.882
7.35 pounds per gallon.

Propeller Load Runs

FIRST RUN

R.P.M.	Actual		Corrected		Temperature °F.				Oil Pressure Lbs./ sq.in.	Air Temp. °F.	Man. Vac. In. Hg.	Carb. Vac. In. Hg.	Gas. Cons.	
					Water		Oil							
	Brake Load Lbs.	B.H.P.	Torque Lbs./ Ft.	H.P.	In	Out	In	Out					Sec. for 3 Lbs.	Lbs. Hp. Hr.
1620	333	179.9	597	184.2	145	159	100	105	47	45	1.15	0.8	123.4	.487
1490	291	144.5	521	148.0	146	160	103	110	40	43	3.2	0.5	136.8	.546
1400	254	118.5	456	121.3	143	155	106	112	37	40	6.0	0.3	139.2	.655
1290	223	95.9	401	98.2	147	157	106	112	34	41	6.1	0.2	125.4	.739
1210	189	76.3	339	78.2	148	158	105	111	33	41	10.2	0.15	167.4	.846

SECOND RUN

1600	334	178.1	599	182.3	145	159	110	117	40	45	1.15	0.8	123.4	.492
1510	294	148.0	527	151.5	147	160	111	119	36	45	3.3	0.45	135.0	.541
1400	254	118.5	456	121.3	150	160	112	118	34	43	5.7	0.3	136.4	.668
1300	223	96.6	401	99.0	152	160	110	116	32	43	7.9	0.2	150.2	.744
1200	188	75.2	337	77.0	151	159	109	115	31	43	9.6	0.15	165.2	.870

First Run

Length of brake arm	21″
Kind of oil used	U. S. Spec. No. 3501
Specific gravity of gasoline	0.708 at 15° C.
Average barometer	29.22 In. Hg.

Second Run

Length of brake arm	21″
Kind of oil used	U. S. Spec. No. 3501
Specific gravity of gasoline	0.708 at 15° C.
Average barometer	29.22 In. Hg.

Friction Horsepower and Compression Pressure Run

R.P.M.	Corrected Engine B.H.P. (From Curve)	Friction Load Lbs.	F.H.P.	Per cent Mech. Effi-ciency	Comp. Press. Lbs./ sq. in.	Temperature °F.				
						Water		Oil		Air
						In.	Out	In	Out	
175	——	—	—	—	87	158	160	93	100	51
1200	150.0	37.5	15.0	90.9	104	158	160	94	100	—
1300	159.0	41.0	17.8	89.9	108	156	157	94	100	49
1400	167.0	45.0	21.0	88.8	116	155	156	95	102	—
1500	175.0	49.0	24.5	87.7	116	153	155	97	103	49
1600	182.0	53.0	28.3	86.5	122	153	155	98	105	—
1700	188.0	52.0	29.5	86.4	122	153	155	100	106	48
1800	193.5	53.0	31.8	85.9	124	152	155	102	108	—
1900	197.0	56.0	35.5	84.7	118	153	154	102	108	49
2000	199.0	60.0	40.0	83.3	104	153	155	105	112	—

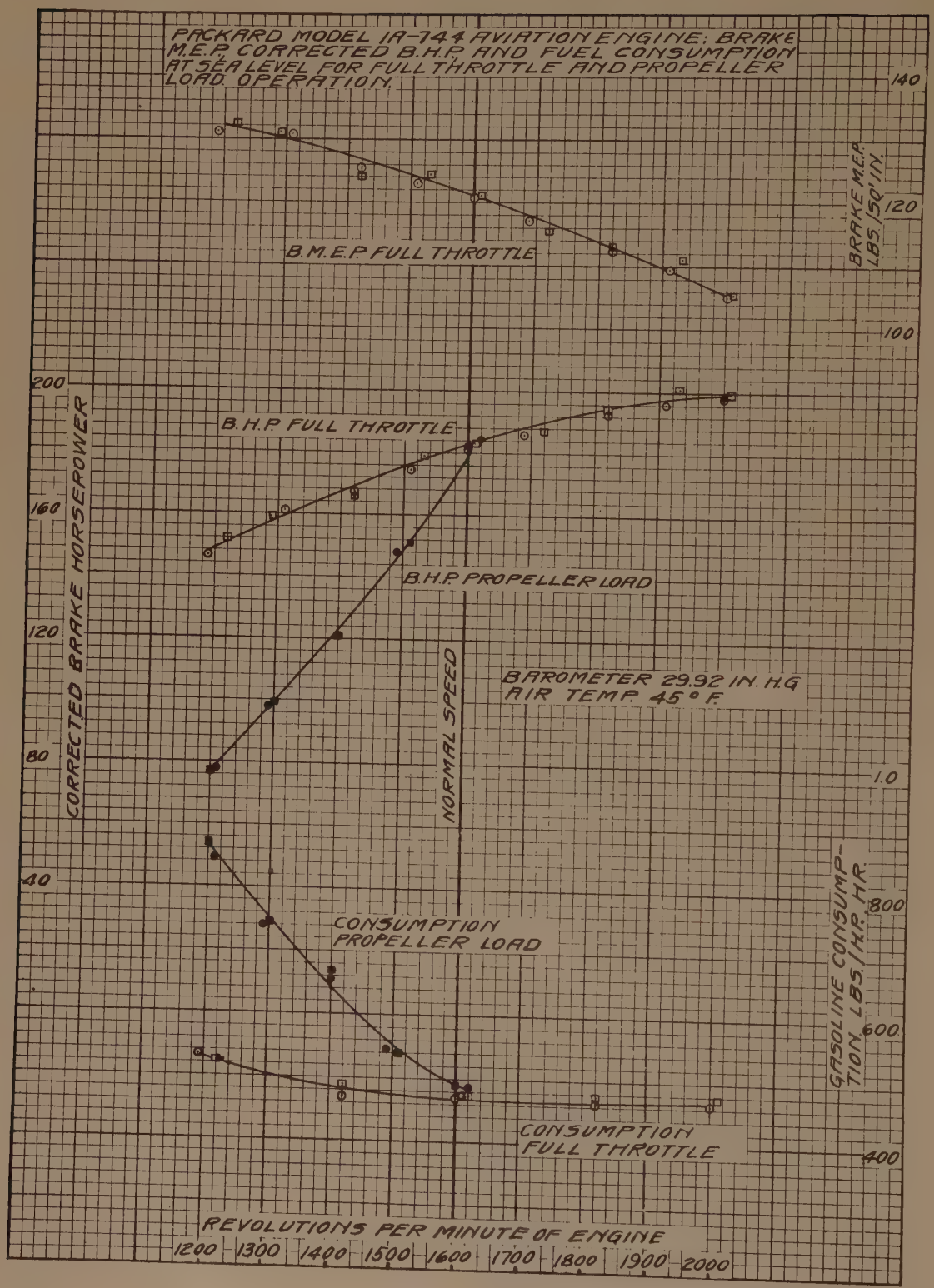
Length of brake arm ..... 21 inches
Kind of oil used ..... U. S. A. Spec. No. 3501
Average barometer ..... 29.21 In. Hg.

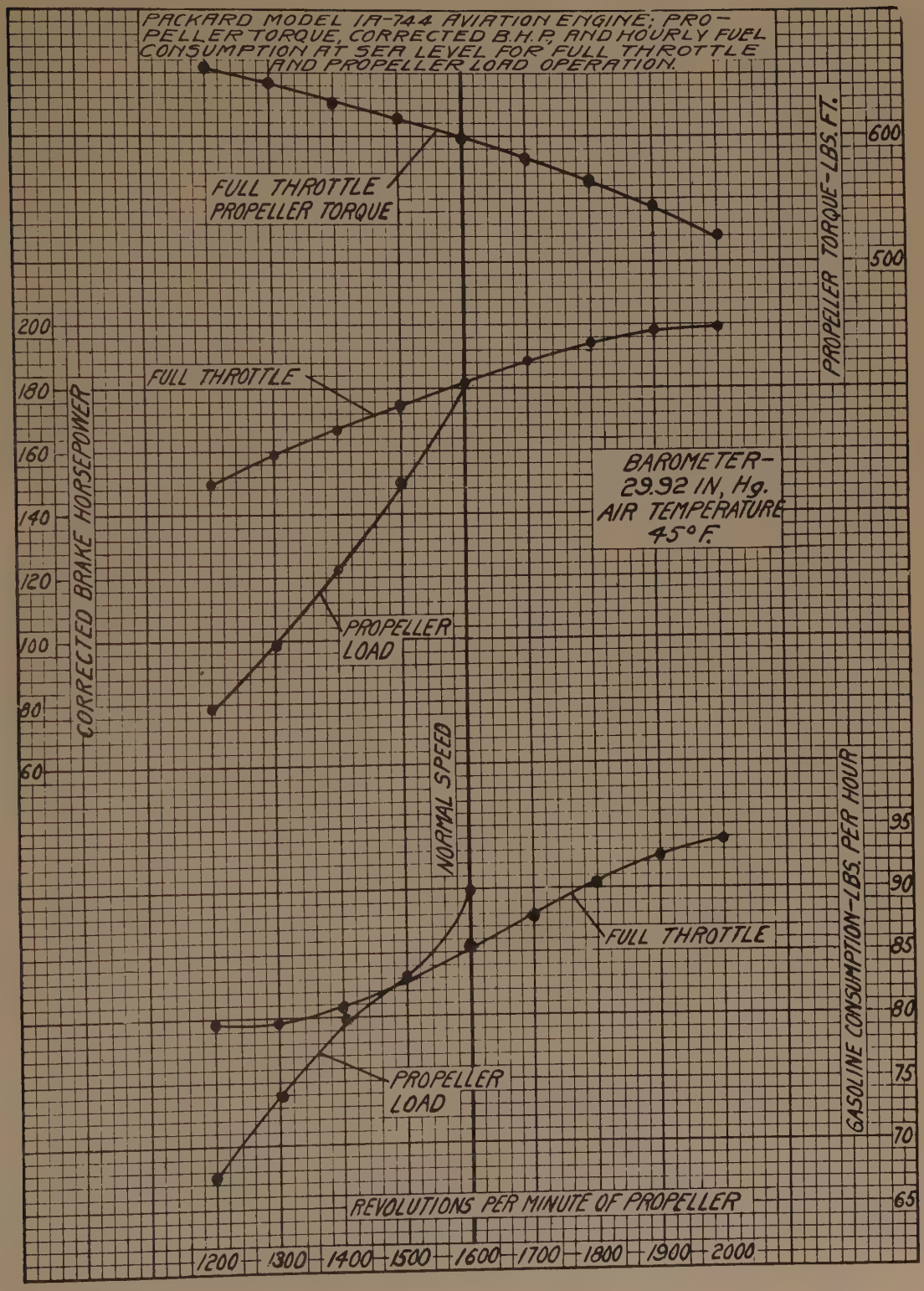
One Hour Fuel and Oil Consumption Run

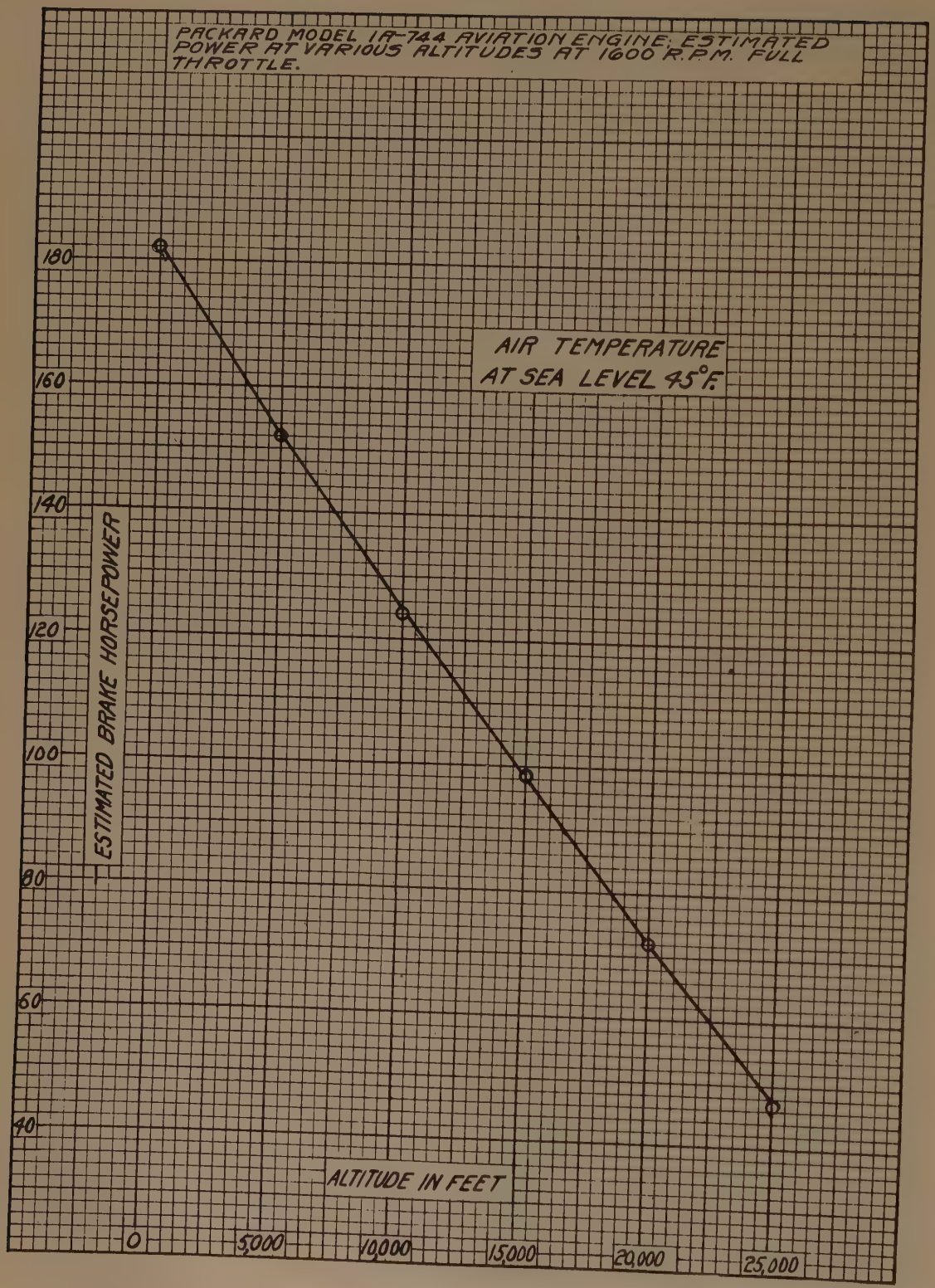
R.P.M.	Actual		Corrected			Temperature °F.				Oil Pressure Lbs. per sq. in.	Carb. Air Temp. °F.	Manifold Vac. In. Hg.	Carb. Vac. In. Hg.	Gas. Cons.		Oil Cons.	
						Water		Oil									
	Brake Load Lbs.	B.H.P.	Torque Lbs. Ft.	H.P.	B.M.E.P. Lbs. per sq. in.	In	Out	In	Out					Lbs. for 5 min.	Lbs./ Hp.Hr.	Lbs. for 5 min.	Lbs./ Hp.Hr.
——	330	——	589	——	119.4	147	160	100	108	52	45	1.20	0.85	—	——	—	——
1616	328	176.6	585	180.0	118.5	148	160	107	115	50	45	1.20	0.85	7.2	.489	0.6	.0408
1616	328	176.6	585	180.0	118.5	147	160	113	122	49	45	1.15	0.85	7.2	.489	1.0	.0679
1602	326	174.1	582	177.5	117.9	146	159	117	127	48	45	1.15	0.85	7.0	.482	0.7	.0482
1612	333	179.0	594	182.5	120.4	148	160	120	130	47	46	1.15	0.85	7.1	.476	0.6	.0402
1610	332	178.2	592	181.6	120.0	147	160	123	133	47	46	1.15	0.85	7.2	.485	0.8	0.538
1616	332	178.9	592	182.3	120.0	146	158	127	136	45	46	1.15	0.85	7.1	.476	0.6	.0402
1604	330	176.4	589	179.8	119.4	150	164	128	136	45	47	1.15	0.85	7.0	.476	1.1	.0748
1614	331	178.1	590	181.5	119.6	146	158	125	131	47	47	1.15	0.85	7.3	.492	1.0	.0674
1604	332	177.5	592	181.0	120.0	147	160	123	129	48	47	1.15	0.85	7.2	.487	0.9	.0608
1604	324	173.2	578	176.5	117.2	145	160	121	127	49	47	1.15	0.85	—	——	0.8	.0554
1614	330	177.6	589	181.0	119.4	148	160	120	127	49	48	1.15	0.85	7.2	.487	1.0	.0676
1618	327	176.4	583	179.8	118.2	146	159	120	126	49	49	1.15	0.85	7.1	.483	0.8	.0544
AVERAGE RESULTS FOR ONE HOUR																	
1611	330	177.2	589	180.6	119.4	147	160	119	127	48	46	1.15	0.85	78.6*	.484	9.9**	.0559

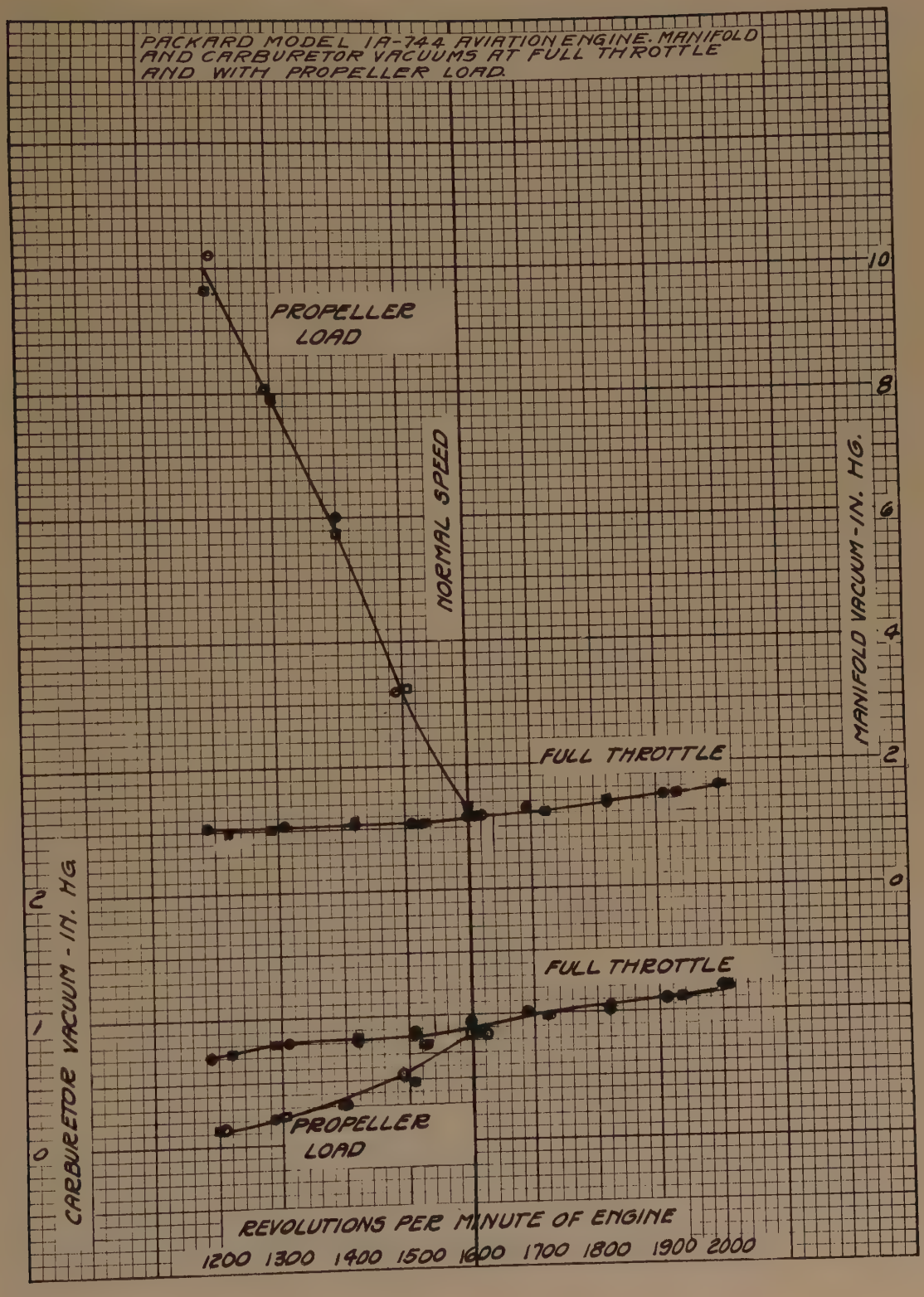
*Total for 55 minutes
**Total for one hour

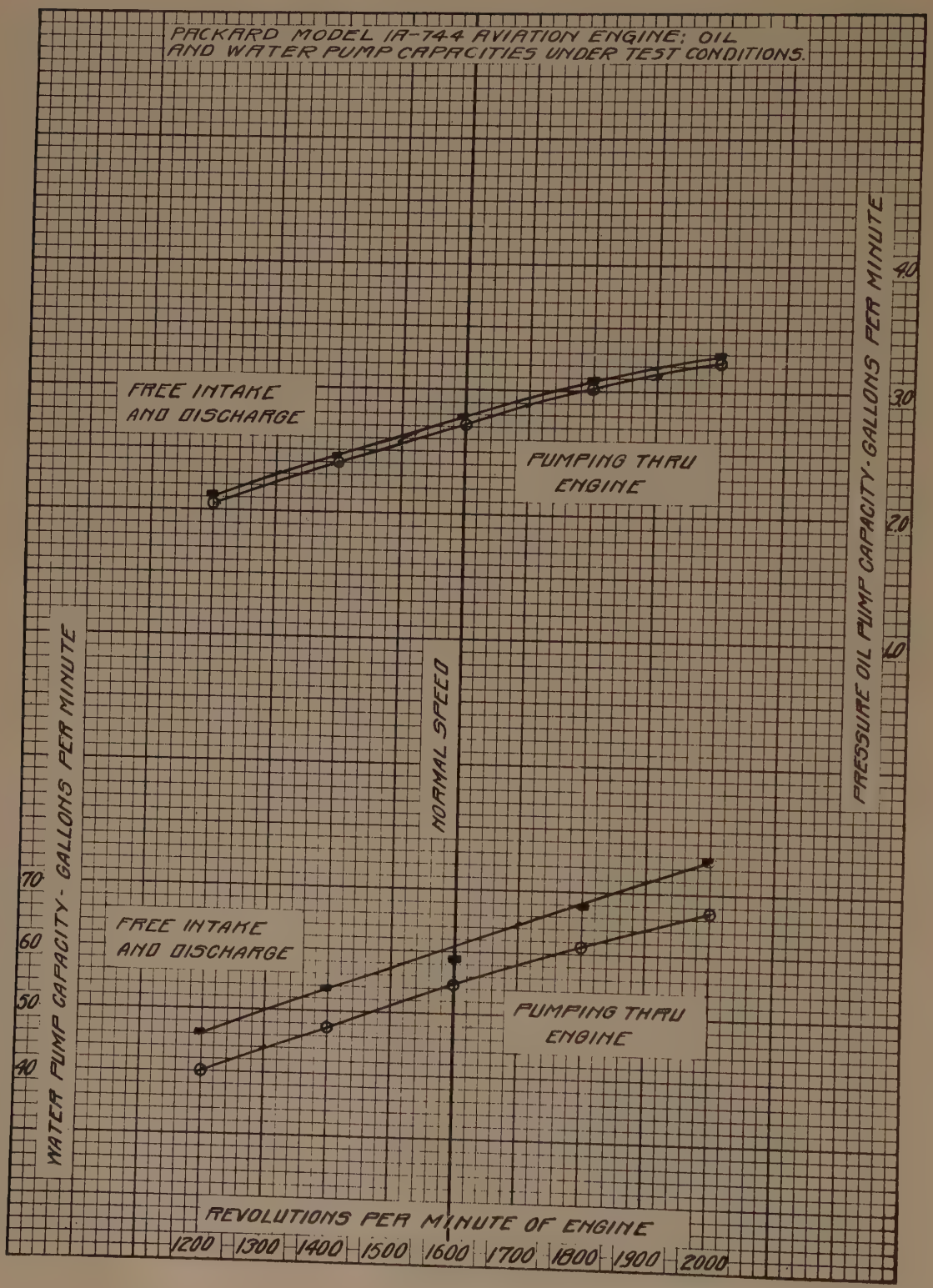
Length of brake arm	21 inches
Oil used	U. S. A. Specification No. 3501
Specific gravity of gasoline	0.708 at 60°F.
Average barometer	29.35 In. Hg.

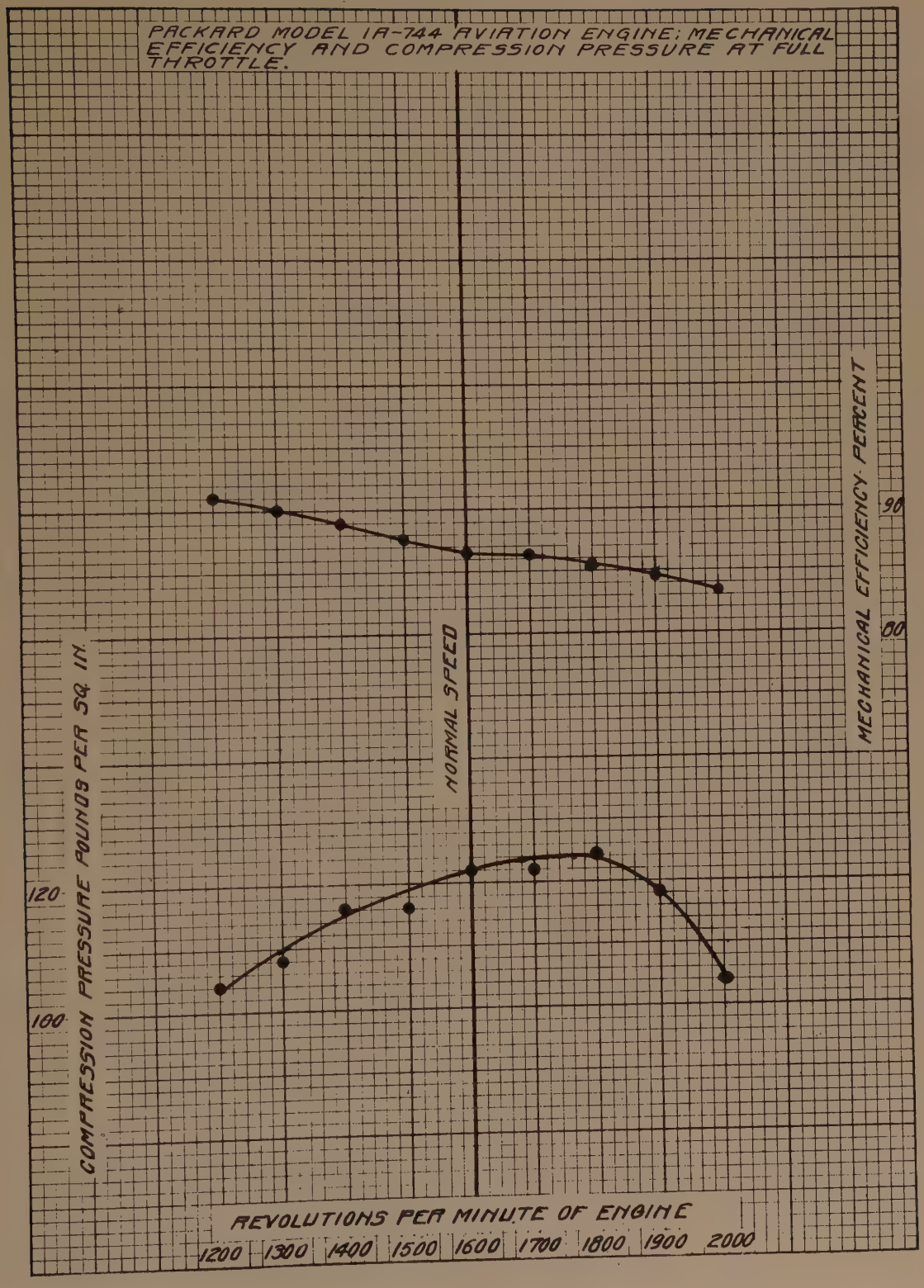

PACKARD MODEL 1A-744 AVIATION ENGINE: BRAKE M.E.P. CORRECTED B.H.P. AND FUEL CONSUMPTION AT SEA LEVEL FOR FULL THROTTLE AND PROPELLER LOAD OPERATION.
B.M.E.P. FULL THROTTLE
B.H.P. FULL THROTTLE
B.H.P. PROPELLER LOAD
NORMAL SPEED
BAROMETER 29.92 IN. H.G.
AIR TEMP. 45° F.
CONSUMPTION PROPELLER LOAD
CONSUMPTION FULL THROTTLE
CORRECTED BRAKE HORSEPOWER
BRAKE M.E.P. LBS./SQ. IN.
GASOLINE CONSUMPTION LBS./H.P. HR.
REVOLUTIONS PER MINUTE OF ENGINE
200
160
120
80
40
140
120
100
1.0
.800
.600
.400
1200
1300
1400
1500
1600
1700
1800
1900
2000


PACKARD MODEL 1A-744 AVIATION ENGINE: PROPELLER TORQUE, CORRECTED B.H.P. AND HOURLY FUEL CONSUMPTION AT SEA LEVEL FOR FULL THROTTLE AND PROPELLER LOAD OPERATION.
FULL THROTTLE PROPELLER TORQUE
PROPELLER TORQUE - LBS. FT.
600
500
200
180
160
140
120
100
80
60
FULL THROTTLE
CORRECTED BRAKE HORSEPOWER
BAROMETER - 29.92 IN. Hg. AIR TEMPERATURE 45° F.
PROPELLER LOAD
NORMAL SPEED
95
90
85
80
75
70
65
FULL THROTTLE
PROPELLER LOAD
GASOLINE CONSUMPTION - LBS. PER HOUR
REVOLUTIONS PER MINUTE OF PROPELLER
1200
1300
1400
1500
1600
1700
1800
1900
2000


PACKARD MODEL 1A-744 AVIATION ENGINE: ESTIMATED POWER AT VARIOUS ALTITUDES AT 1600 R.P.M. FULL THROTTLE.
AIR TEMPERATURE AT SEA LEVEL 45°F.
ESTIMATED BRAKE HORSEPOWER
180
160
140
120
100
80
60
40
ALTITUDE IN FEET
0
5,000
10,000
15,000
20,000
25,000


PACKARD MODEL 1A-744 AVIATION ENGINE. MANIFOLD AND CARBURETOR VACUUMS AT FULL THROTTLE AND WITH PROPELLER LOAD.
PROPELLER LOAD
NORMAL SPEED
FULL THROTTLE
FULL THROTTLE
PROPELLER LOAD
MANIFOLD VACUUM - IN. HG.
CARBURETOR VACUUM - IN. HG
REVOLUTIONS PER MINUTE OF ENGINE
1200 1300 1400 1500 1600 1700 1800 1900 2000
0
2
0
2
4
6
8
10


PACKARD MODEL 1A-744 AVIATION ENGINE: OIL AND WATER PUMP CAPACITIES UNDER TEST CONDITIONS.
FREE INTAKE AND DISCHARGE
PUMPING THRU ENGINE
NORMAL SPEED
PRESSURE OIL PUMP CAPACITY - GALLONS PER MINUTE
40
30
20
10
WATER PUMP CAPACITY - GALLONS PER MINUTE
70
60
50
40
FREE INTAKE AND DISCHARGE
PUMPING THRU ENGINE
REVOLUTIONS PER MINUTE OF ENGINE
1200
1300
1400
1500
1600
1700
1800
1900
2000


PACKARD MODEL 1A-744 AVIATION ENGINE: MECHANICAL EFFICIENCY AND COMPRESSION PRESSURE AT FULL THROTTLE.
COMPRESSION PRESSURE POUNDS PER SQ. IN.
120
100
NORMAL SPEED
MECHANICAL EFFICIENCY: PERCENT
90
00
REVOLUTIONS PER MINUTE OF ENGINE
1200 1300 1400 1500 1600 1700 1800 1900 2000

Tear-Down Inspection

At the completion of the standard engine tests, the engine was completely disassembled for inspection. A detailed report of the condition of the various parts follows:

Crankcase—Inspection of the two halves of the crankcase showed some slight movement of the two cases at the center bearing and forward. No cracks were noticed in the case and, aside from this slight moving, the case seemed to be in good condition. The gaskets used between the upper and lower passages of the intake manifolds were not functioning, as they were thinner than the recess into which they were placed.

Crankshaft—The crankshaft journals and thrust bearing were in good condition.

Connecting Rods—The connecting rods were all in good condition. The bearings were also satisfactory with the exception of one crankpin bearing in which the babbitt had become loose on the bronze in several places.

Pistons—The condition of the piston skirts is not considered satisfactory. They were exceedingly black, which may be due to one of two causes; either the clearance is too great, or the cooling of the pistons insufficient. Several piston rings were found to be broken, which is mainly due to the original fit of the rings in the grooves. The rings showed especially poor bearing surfaces at the gaps. There was considerable carbon on the heads of all the pistons and a small coating on the under side of the heads.

Cylinders—The cylinder bores were not in good condition, showing slight signs of heat at the lower end and poor machining. There was considerable carbon all over the combustion chamber. The exhaust valve seats were pitted on the low side.

Valves—The stems of the valves were considerably scored, but it is not at all unlikely that this scoring may be due to poor workmanship in fitting the guides in the first place.

Valve Gear—The valve gear appeared to be in good condition throughout.

Lubrication System—The lubrication system appeared to have been functioning properly, as all the bearing surfaces had received lubrication. The space between the generator drive housing and the drive shaft bearing was found to be filled with oil. This undoubtedly caused the oil leakage around the generator drive, which has been noted under observations on test.

Analysis of Engine

Design—The design of the engine is compact, and the various parts are amply strong as well as accessible. The performance is good. The principal criticisms from a training engine standpoint are the non-adjustability of the bearings, and the large number of parts.

Adaptability to Production—The design of the engine involves for the most part straightforward machine work and it is, therefore, considered that the engine is adapted to quantity production.

Performance—The performance of the engine on the dynamometer was satisfactory in regard to power and fuel consumption. The oil consumption was excessive. Vibration was rather pronounced, but no definite decision can be made on this point until the engine is mounted in an airplane. The mixture control of the carburetor is not of sufficient range. It is not within the scope of this report to deal with the durability of this engine, as this will be covered in a report on the 50-hour duration test.

Adaptability to Airplane—This engine provides for straightforward mounting, requiring only two engine bed timbers. By removing the carburetor it is possible to slide the engine in and out on the bed timbers. The head resistance is comparatively low and the visibility good, particularly so on account of the short cylinders and the fact that it is possible to look between the cylinders of the engine through the "V."

Accessibility—The accessibility of the essential parts of the engine for adjustment and inspection is good. The carburetor is unusually accessible for a "V" type engine, and permits of gravity gasoline feed.

EXPERIMENTAL

EXPERIMENTAL

ASPECT RATIO TEST

Object of Test

The object of this test was to determine the effect of aspect ratio on the "lift" and "drag" of a model aerofoil, and to establish correction factors for varying aspect ratio, monoplane and biplane, for use in design. Previous test had covered the case for the monoplane, but no information was available for the biplane case.

Numerous theoretical considerations have been advanced by such authorities as Alexander See, Lanchester, and others upon the effect of aspect ratio, but no very definite conclusions have been reached. A short comparison of results contained in this report with those of previous tests is given under the heading of Computations and Comparisons.

It is regretted that lack of alignment of the balance trumpet top in wind tunnel, caused all measurements relative to center of pressure movement to be in error by an amount, although constant, yet of a nature indeterminant. Results for variations of center of pressure movement with aspect ratio are therefore omitted. It is believed that this variance is practically negligible.

In previous reports it has been pointed out that aspect ratio corrections vary with the shape of the aerofoil section, being greater for the more efficient lift sections and less for those sections giving small "lift" and "drag." The section tested, R.A.F. No. 6, is fairly representative of present day practice with possible slight refinement of contour, and the tabulated correction factors may be used with a reasonable degree of confidence insofar as their validity is dependent on shape.

Models and Methods

The area of the channel, sixteen square feet, necessarily restricted the range of aspect ratio tested, the cross sectional velocity near the walls not being of the same value as at the tunnel center due to interference. The largest aspect ratio tested, twelve, is open to conjecture due to this cause, and values derived for it are probably slightly more in error than for the other cases.

The R.A.F. No. 6 was selected for this work, as it represents, as has been stated, the trend of the period in wing design, and further suggested a ready means of comparison with previous tests. Two accurate aluminum wings were scraped to this contour within a tolerance of $\pm.0002''$, having a chord of 2.25″ and an aspect ratio of 12. With chord constant the aspect ratio was varied from 12 to 3, thus covering the whole range of aspect ratio likely to be used in airplane design. Results for aspect ratio 3 are not tabulated as they were employed only for curve fairing.

In the monoplane tests the wing was supported in the conventional manner, its end being threaded to a 5/16″ spindle, due allowance being made for spindle drag. At large angles of incidence approaching the region of discontinuity the slenderness of the wing caused a perceptible flutter. Obviously errors were introduced in recorded observations, and correction factors for large incidence were rejected as being worthless from a precision viewpoint.

Experimental

In previous tests where wooden wings were employed it was found impossible to obtain values for aspect ratios higher than eight, due to lack of rigidity of the wing, and various artifices for stiffening the wing to prevent fluttering were resorted to, as wires, etc., doubtful allowances and corrections for their presence being made.

Biplane combination twelve to four, with "gap-chord" ratio of 1, was also tested. The wings were supported in biplane in the conventional manner by tie-struts at the extremities of the wings. For large aspect ratio a center spacer-strut was used to prevent buckling, and correction for its interference made.

The wings, monoplane and biplane construction, were lined to within 1/20 of a degree. In the case of the biplane, resistance of the upper strut was determined by making a run at low angles of incidence with upper strut removed.

The difference between the drag of this run and the run with strut in place was taken as strut resistance. Similar methods were employed in finding drag due to spacer-strut. The resistance of the lower strut was determined by running the strut without the wing.

Each aspect ratio was lined up and run three separate times and the weighted mean taken as the best representative value. These runs agreed within $\pm 1\%$ so that the mean value can be assumed to be correct within 1%.

Tabulations and Computations

"Lift" and "drag" and "L/D" correction factors are listed for the case of the monoplane in Tables 1 and 3 respectively.

"Lift" and "drag" and "L/D" correction factors are listed for the case of the biplane in Tables 4 to 6.

Conversion factors from monoplane to biplane are given in Tables 7 to 9.

Correction factors for all cases were derived from faired curves.

Comparison of Results

As a check on the accuracy of recorded observations several previous experiments for which data were available were consulted.

In a previous monoplane aspect ratio test (Ref. 1), at the Institute's Aerodynamical Laboratory, wing section R.A.F.-6 was tested for the range 6 to 11.75 aspect ratio. The overhang test conducted at the same laboratory for the Army (Ref. 2), presents a further check. Considering the case of maximum "L/D" at 4° alone, for the sake of brevity, and denoting these prior tests as (1) and (3), and the present run (Ref. 3) as (2), we have the following comparison for conversion factors for monoplane aspect ratio.

A. R.	4	5	6	7	8	9	10	11	12
Test No. 1	—	—	100	107	115	122	133	138	—
Test No. 2	76	88	100	107	116	124	132	140	150
Test No. 3	—	92	100	106	115	124	—	—	—

This comparison shows the percentage correction factors for tests 1, 2 and 3 to be practically identical, and as the comparison at angles other than 4° were shown to be similarly concordant, it is felt that Tables 1, 2 and 3 of this report are fair values for the case considered.

The correction factors for conversion from monoplane to biplane (see Tables 7, 8, 9) were compared with the Navy biplane correction, based on N.P.L. observations (Ref. 4).

At 4°, aspect ratio 6, the "L/D" correction factor for monoplane to biplane is given as 82%, and the correction for "gap/chord" ratio 96.6%; then 82% x 97% equals 79%. The value obtained from the run under consideration (Ref. 5) gives the correction factor for this particular aspect ratio as 75%, a difference of 4%. This is well within experimental error, the error being due in part to difference of "LV" ratio in the two tests under consideration, the "LV" ratio for this run being slightly lower than the N.P.L. Similarly for 4° "K_y," aspect ratio 6, Navy correction = 85% x 96.4% = 82%, as against a correction of 81% (see Table No. 7).

The percentage difference for correction factors from monoplane to biplane with an aspect ratio of 6 for angles other than 4° are all within 3%, showing close agreement.

Unfortunately there are no correction factors for monoplane to biplane, other than for aspect ratio 6, available for comparison. A Navy note (Ref. 6) assumes that the correction factor for aspect ratio is practically constant for all angles of incidence, one of the conclusions deduced from the present run. It is further stated in report No. 115 that results indicate that the aspect ratio correction factor as applied to monoplane values are valid for biplane and triplane combinations. The tabulated results given in this report (Ref. 7) seem to be at variance with this viewpoint, tending as pointed out under conclusions to favor the biplane arrangement with increased aspect ratio.

The low value of "lift/drag" obtained for these aerofoils for aspect ratio 6, 15, as compared with that of an 18 x 3 model, 16.7, is due to a difference of "LV" ratio. For the case under consideration "LV" = 2.25 x 30 = 67.5, and for the standard model "LV" = 30 x 3 = 90. The ratio of "LV" = 67.5/90 = 75 and the ratio of maximum "L/D" = 15/16.7 = 90, a loss of 10%.

References

1. Blakemore's thesis on aspect ratio.
2. McCook Field Bulletin.
3. Enclosed report Table No. 3.
4. See Aircraft Technical Note No. 112 (Bureau Construction and Repair).
5. Enclosed report Table No. 9.
6. See Aircraft Technical Note No. 115 (Bureau Construction and Repair).
7. See Tables 7, 8, 9 of enclosed report.

Discussion and Conclusions

As no corrections were necessary for supporting appendages in the case of the monoplane it is felt that values derived were more concordant with facts than those obtained in previous tests. Great care was exercised for the case of the biplane in allowing for strut correction, and it is thought that for both cases the values given are accurate within the precision of the balance, and are believed to be representative for the cases considered.

The following conclusions are evident:

1. The maximum "L/D" ratio for all aspect ratios occurs at an angle of incidence of 4°, or within indeterminate limits as regards balance observation readings.

2. The most important effect of aspect ratio is that the maximum "L/D" ratio exhibits constant improvement with increased aspect ratio; it follows directly that the general aerodynamical efficiency of a machine improves with aspect ratio.

3. The "L/D" for *all* flight angles improves with increasing aspect ratio.

4. Maximum "K_y" increases slightly with aspect ratio and the critical angle occurs earlier in aerofoils of larger aspect ratio and may be a contributing factor to the non-attainment of high values of lift in deeply cambered aerofoils of large aspect ratio.

5. The fact that at the angles of maximum lift, the lift coefficients are only slightly affected by aspect ratio would tend to show that landing speeds are only slightly affected by aspect ratio.

6. Lift coefficients at other angles of incidence show marked improvement with increasing aspect ratio.

7. With reference to Table 1, it is seen that for the usual flight angles aspect ratio corrections may be considered as independent of incidence.

8. For large aspect ratios, biplane combinations compare most favorably with monoplane. This doubtless is due to partial elimination of tip loss and less mutual interference between wings.

9. For both biplane and monoplane a general improvement in aerodynamical efficiency is obtained by increased aspect ratio. Structural considerations for both cases, however, restrict the designer in his choice. For the small airplane 8 would seem a reasonable limit. For the large airplane larger aspect ratio might be employed to advantage as structural limitations, especially with regard to the biplane, are not so severe.

10. With an aspect ratio of 12 "L/D" at 4° was found to be 21.6. The gain in efficiency is due to diminution of drag with increased aspect ratio.

TABLE 1

Monoplane

Aspect Ratio K_y Corrections*

A. R.	4	5	6	7	8	9	10	11	12
0°	83	94	100	102	108	108	111	113	117
2°	84	94	100	103	109	113	117	123	127
4°	86	95	100	103	107	111	114	117	120
6°	87	95	100	104	107	111	114	116	118
8°	88	96	100	104	107	109	113	115	118
10°	89	96	100	103	106	108	111	114	117
12°	90	96	100	103	105	107	109	110	113
14°	91	97	100	101	103	104	104	97	89
16°	101	104	100	92	88	87	86	—	—

**Percentage corrections based on monoplane aspect ratio 6; values derived from faired curves.*

TABLE 2

Monoplane

Aspect Ratio K_x Corrections*

A. R.	4	5	6	7	8	9	10	11	12
0°	105	102	100	99	98	95	93	91	88
2°	111	106	100	98	94	90	88	84	82
4°	113	109	100	96	93	90	87	84	80
6°	113	105	100	96	93	90	87	85	84
8°	111	105	100	96	91	90	87	85	84
10°	111	105	100	95	91	89	87	85	83
12°	111	105	100	95	91	89	87	85	82

**Percentage corrections based on monoplane aspect ratio 6; values derived from faired curves.*

TABLE 3

Monoplane

Aspect Ratio L/D Corrections*

A. R.	4	5	6	7	8	9	10	11	12
0°	79	93	100	103	111	114	120	124	133
2°	76	88	100	105	116	127	133	147	154
4°	76	88	100	107	116	124	132	140	150
6°	77	90	100	108	116	124	131	136	140
8°	81	91	100	108	116	124	130	135	140
10°	81	91	100	108	115	121	126	135	140
12°	82	91	100	107	115	120	125	130	137

**Percentage corrections based on monoplane aspect ratio 6; values derived from faired curves.*

TABLE 4

Biplane

Aspect Ratio K_y Corrections*

A. R.	4	5	6	7	8	9	10	11	12
0°	87	95	100	105	111	116	121	124	126
2°	86	94	100	106	113	118	123	126	129
4°	86	93	100	105	109	114	117	119	122
6°	87	94	100	104	108	111	114	115	117
8°	87	95	100	104	108	110	113	115	117
10°	87	95	100	104	108	110	113	115	117
12°	88	96	100	104	108	110	113	115	116
14°	89	95	100	104	107	109	111	112	110
16°	91	93	100	102	101	98	95	94	94

**Percentage corrections based on biplane aspect ratio 6; values derived from faired curves.*

TABLE 5

Biplane

Aspect Ratio K_x Corrections*

A. R.	4	5	6	7	8	9	10	11	12
0°	100	100	100	100	98	96	93	88	84
2°	103	101	100	99	98	92	88	82	78
4°	103	101	100	98	95	92	88	84	79
6°	105	103	100	97	95	92	89	86	84
8°	105	103	100	97	95	92	89	87	86
10°	107	104	100	97	94	90	89	87	85
12°	108	104	100	97	94	90	89	87	85
14°	109	105	100	97	93	91	90	92	94
16°	118	105	100	99	101	105	109	114	119

**Percentage corrections based on biplane aspect ratio 6; values derived from faired curves.*

TABLE 6

Biplane

Aspect Ratio L/D Corrections*

A. R.	4	5	6	7	8	9	10	11	12
0°	87	92	100	106	113	120	130	137	147
2°	83	92	100	111	120	129	138	147	156
4°	83	92	100	108	116	123	132	140	152
6°	84	92	100	108	116	123	130	136	143
8°	83	92	100	108	116	123	130	136	140
10°	83	92	100	108	116	124	130	134	138
12°	83	92	100	108	116	124	130	134	136

**Percentage corrections based on biplane aspect ratio 6; values derived from faired curves.*

TABLE 7

Aspect Ratio

Monoplane to Biplane Corrections (K_y)

A. R.	4	5	6	7	8	9	10	11	12
0°	87	84	83	85	85	89	93	93	90
2°	82	80	80	82	85	88	86	83	81
4°	81	80	81	83	85	85	85	82	82
6°	83	82	83	83	84	84	83	83	83
8°	82	82	83	83	84	85	83	83	83
10°	81	82	83	84	84	86	85	84	84
12°	81	83	83	84	85	88	87	87	87

TABLE 8

Aspect Ratio

Monoplane to Biplane Corrections (K_x)

A. R.	4	5	6	7	8	9	10	11	12
0°	106	109	111	112	111	112	111	109	106
2°	106	109	114	115	118	116	114	112	110
4°	99	101	109	110	112	111	110	109	108
6°	99	104	106	107	108	108	108	107	106
8°	95	99	100	101	103	102	102	102	101
10°	96	99	100	102	103	101	102	102	101
12°	97	100	100	102	102	101	103	102	102

TABLE 9

Aspect Ratio

Monoplane to Biplane Corrections (L/D)

A. R.	4	5	6	7	8	9	10	11	12
0°	83	76	75	77	79	81	85	88	89
2°	78	72	71	77	75	73	76	71	73
4°	81	75	75	75	74	75	74	74	76
6°	86	81	79	79	79	80	80	79	82
8°	85	85	83	83	83	84	83	82	83
10°	85	85	83	83	83	86	87	83	82
12°	85	85	83	83	84	87	88	87	82

INVESTIGATION OF MATERIALS AND CONSTRUCTION OF FOKKER D-VII FUSELAGE

Purpose

The purpose of this investigation was to determine, by testing, the following points:

1. Characteristics and general properties of the materials used.
2. Character and efficiency of the joining and welding of parts.
3. Strength of individual parts as used in the fuselage.
4. Dimensions of the various wires and tubing.
5. General construction and dimensions of the fuselage as a unit.

Conclusions

The physical properties of the wire used for bracing in the fuselage are practically identical with those of the wire specified in Air Service Specification No. 10276 for High Strength Steel Wire.

The steel tubing is not uniform and varies in physical properties from 52,960 pounds per square inch to 82,260 pounds per square inch in tensile strength, and from 6% to 20% elongation in 2 inches.

The fractures were often very coarse grained, indicating that no particular care was taken in the selection of the tubing. The variation in chemical analysis is considerable, and covers a range of from fifteen to twenty points in carbon content. The sulphur content is higher than allowed in American practice.

The welds tested in tension indicate that the welded joint is uniformly as strong, or stronger, than the component parts.

Material

The material for the various tests was distributed as follows:

PHYSICAL TESTING BRANCH.

Wires and steel tubing from the Fokker D-VII.

METALLURGICAL BRANCH.

A welded 90 degree joint (Specimen 224, Fig. 9) in the tubing in the fifth bay of the fuselage of the Fokker D-VII.

CHEMICAL BRANCH.

Steel streamline tubing from the Fokker D-VII landing gear strut.

Procedure

The procedure of the different branches in testing the specimens is as follows:

PHYSICAL TESTING BRANCH.

Specimens of all sizes of tubing and wires, and of typical representative parts, joints, welds and sub-assemblies were taken from throughout the fuselage and given physical tests in the usual manner. All special parts were tested in their proper working angles.

Photographs were made of the fuselage as received. A complete drawing, to scale, was made (Fig. 1) of the fuselage, showing the construction and the method of identifying the various bays by station numbers. All tubing and wires were carefully cleaned, and measured with micrometers.

METALLURGICAL BRANCH.

A longitudinal section was taken through the horizontal strut of the fifth bay so that it cut through the weld that attached it to the longeron. This section was designated as specimen No. 1. Specimen No. 2 was also a longitudinal section taken at the center of the same horizontal strut to illustrate the structure of the tubing unaffected by the welding.

The specimens were polished in the usual way. The etching reagent was a saturated solution of picric acid in alcohol, to which a few drops of nitric acid had been added. The micro-photographic work was conducted on the Bausch and Lomb apparatus.

CHEMICAL BRANCH.

The samples for the chemical analysis were taken from the streamline tubing of the landing gear struts.

Results

PHYSICAL TESTING BRANCH.

Wires—Four sizes of steel wires were used in the fuselage as follows:

Diam. .078″—Wires in engine, tank, and cockpit section.
Diam. .069″—Wires in the sides of the three bays to rear of cockpit, and in cross section at rear of cockpit.

Diam. .059″—Wires in two tail bays, and in sides of three bays to rear of cockpit.

Diam. .052″—Wires in cross sections at stations 7, 8, and 9.

Double wires were used, being laced through the loops at the stations. The two ends were then united by bronze turnbuckles, which are only half the size that would otherwise be required.

With the exception of the .052″ wires all were pulled double, and assembled with turnbuckles just as they were used in the fuselage. For that reason they were all broken in bends, either at loop or at turnbuckle eyes, and showed lower material values than did the .052″ wire.

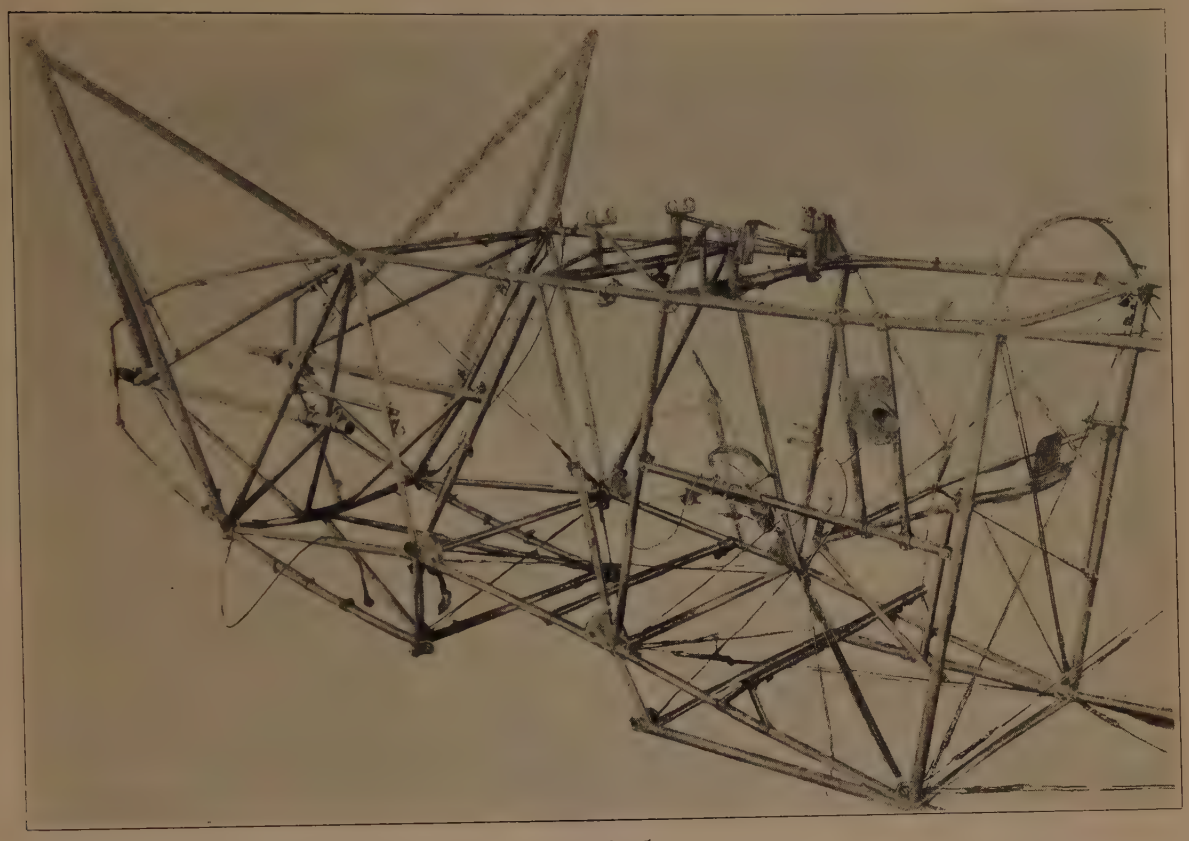


FIG. 5

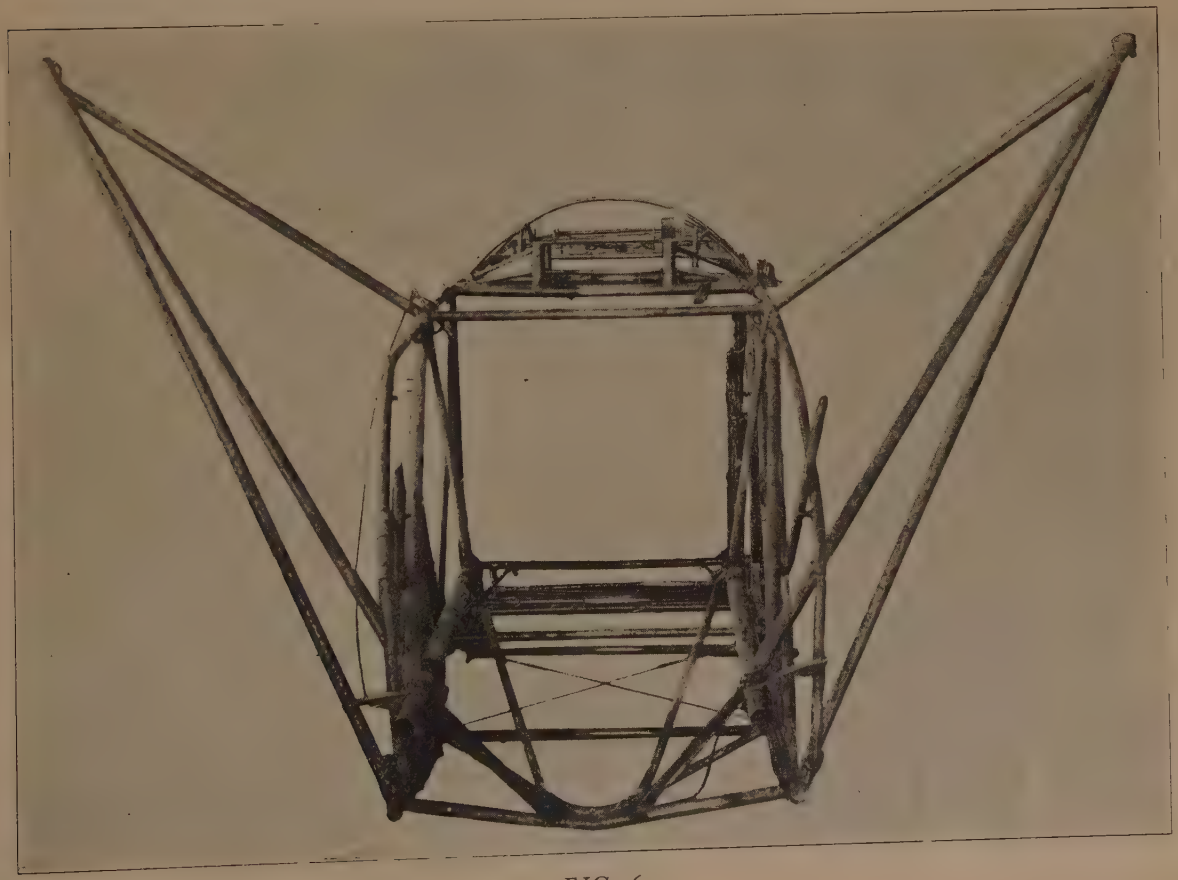


FIG. 6

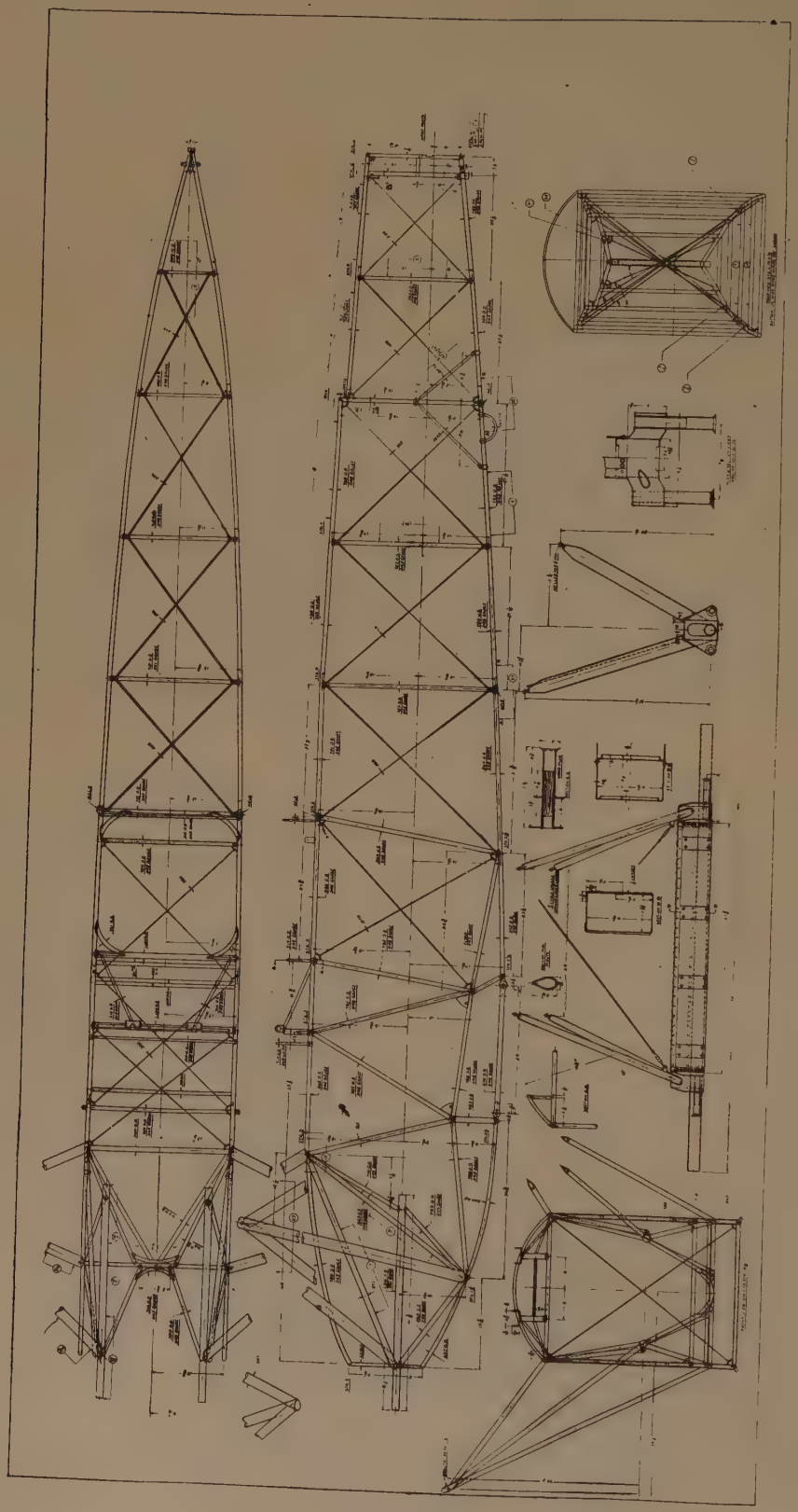


FIG. 1

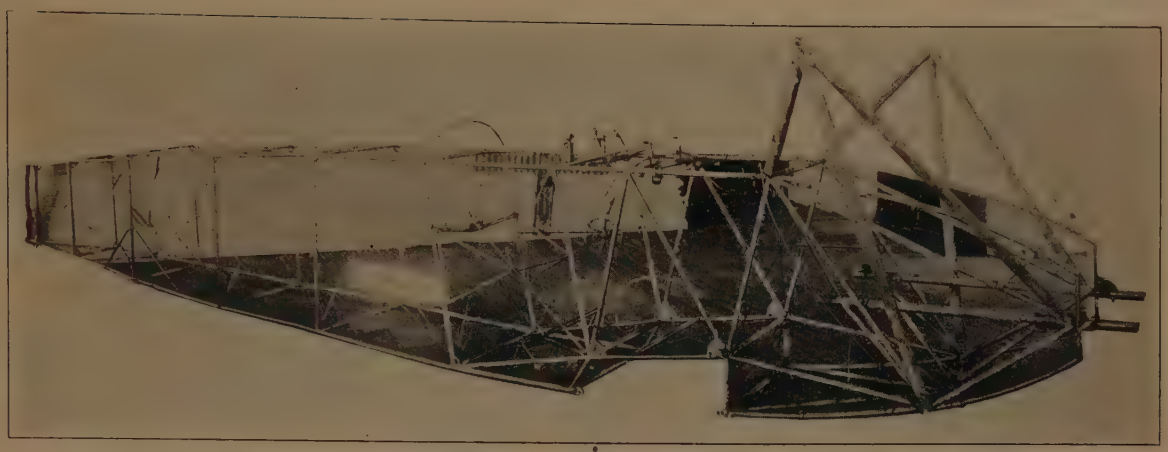


FIG. 7

The following results were obtained:

Wires—Steel—Fuselage Truss Wires—Figure 2

General Specifications:						
Number of Specimen	33	26	27	28	29	30
Description of Specimen	Single			Pulled Double		
Diam., Orig., Inches	.052	.059	.059	.066	.079	.079
Cross Sectional Area, Orig., Sq. In.	.00212	.00273	.00273	.00342	.00490	.00490
Total, Sq. In.	——	.00547	.00547	.00684	.00980	.00980
Tension—						
Yielding Pt., Lbs.	——	1,300	1,360	1,400	2,000	2,060
Yielding Pt., Lbs./Sq. In.	——	237,660	248,680	204,680	204,080	210,200
Maximum Load, Lbs.	710	1,420	1,450	1,585	2,200	2,270
Ult. Str., Lbs./Sq. In.	334,900	259,600	265,080	231,730	224,490	231,630
Location of Fracture	O.S.T.*	Terminal	Terminal	Terminal	End of Loop	Terminal
Character of Fracture	Cup	Square	Square	Square		Square
Torsion—						
Angle of Twist Revs.	42	43	—	40	26.5	—
Bent Test at 90° Angle	10	24	17	24	200	18

Note—Areas were doubled because wires were pulled double.

*O.S.T.—Outside Third.

Machines used—20,000 lbs. Olsen, Tension and Compression.
3,000 in. lbs. Olsen, Torsion.

Turnbuckles—Since turnbuckles showed no signs of weakness when pulled with wires separate tests were not run.

Steel Tubes, Plain Round—The Fokker D-VII fuselage was built of round steel tubing of the following sizes:

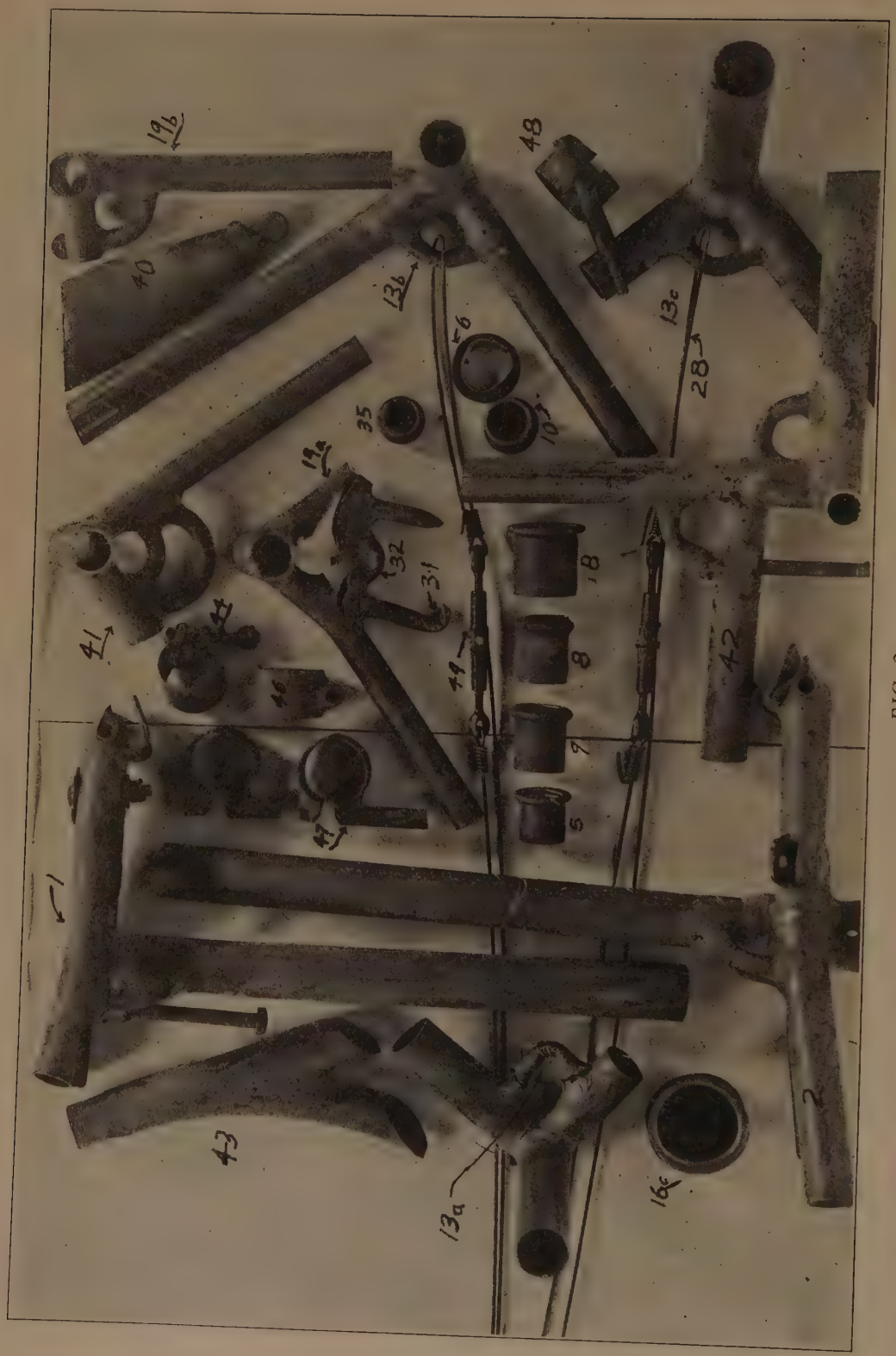

19b
40
13b
26
48
13c
28
35
10
19a
32
31
18
41
44
8
11
42
46
9
47
5
1
43
2
13a
16c

FIG. 2

Diameter	Range of Variations	Approximate mm.
.510″	.508 to .510	13
.549″	.549	14
.595″	.592 to .598	15
.640″	.637 to .640	16.5
.710″	.707 to .714	18
.788″	.786 to .793	20
.868″	.863 to .879	22
.983″	.983	25
1.105″	1.105 to 1.106	28
1.341″	1.341	34

Representative specimens from various points in the fuselage were tested with the following results.

Tubing—Round, Clear, Straight Specimens, Figures 2, 3 and 4

General Description—							
Number of Specimen	35	36a	36b	5	10	9	7
Description of Specimen	Tubing	Tubing	Tubing	LS Strut	Bottom	Strut	Strut
Stations	8	8	Dup.	9	6	7	7–8
Gauge Thickness, Ins.	.054	.049	.049	.096	.082	.090	.042
Outside Diam., Orig., Ins.	.524	.520	.520	.597	.712	.717	.797
Inside Diam., Orig., Ins.	.416	.422	.422	.501	.630	.627	.713
Thickness, 2 x gauge, Ins.	.108	.098	.098	.048	.041	.045	.084
Cross Sectional Area, Orig., Sq. Ins.	.07973	.07251	.07251	.08279	.08643	.09500	.09962
Tension Test—							
Yielding Point, Lbs.	4,620	3,600	4,520	4,590	2,790	4,130	4,500
Yielding Point, Lbs./Sq. In.	57,946	49,648	62,336	55,441	32,280	43,474	45,172
Maximum Load, Lbs.	4,870	3,840	4,930	6,090	7,110	7,110	7,210
Ult. Str., Lbs./Sq. In.	61,080	52,960	67,990	73,560	82,260	74,840	72,380
Elongation, % in 8″	——	——	5.6	4.5	——	8.1	17.2
% in 6″	4.8	4.7	——	——	——	——	——
% in 4″	——	——	8.2	6.7	——	10.1	——
% in 2″	11.5	13.5	12.5	11.5	——	13.5	20.0
% in 1″	20.0	26.0	——	——	——	——	25.0
	——	——	——	O.K.	O.K.	O.K.	——
Location of Fracture	O.S.T.*	I.G.	I.G.		O.S.G.	O.S.T.	O.S.G.
Character of Fracture	Jagged	Jagged	Jagged		Jagged	Diag.Jag.	
Compression Test—							
(1½ x Diam.) 1				.895	1.071	1.071	——

Machine used—20,000 Olsen, Tension and Compression.

*O.S.G.—Outside Gauge.

O.S.T.—Outside Third.

I.G.—In Grip.

M.T.—Middle Third.

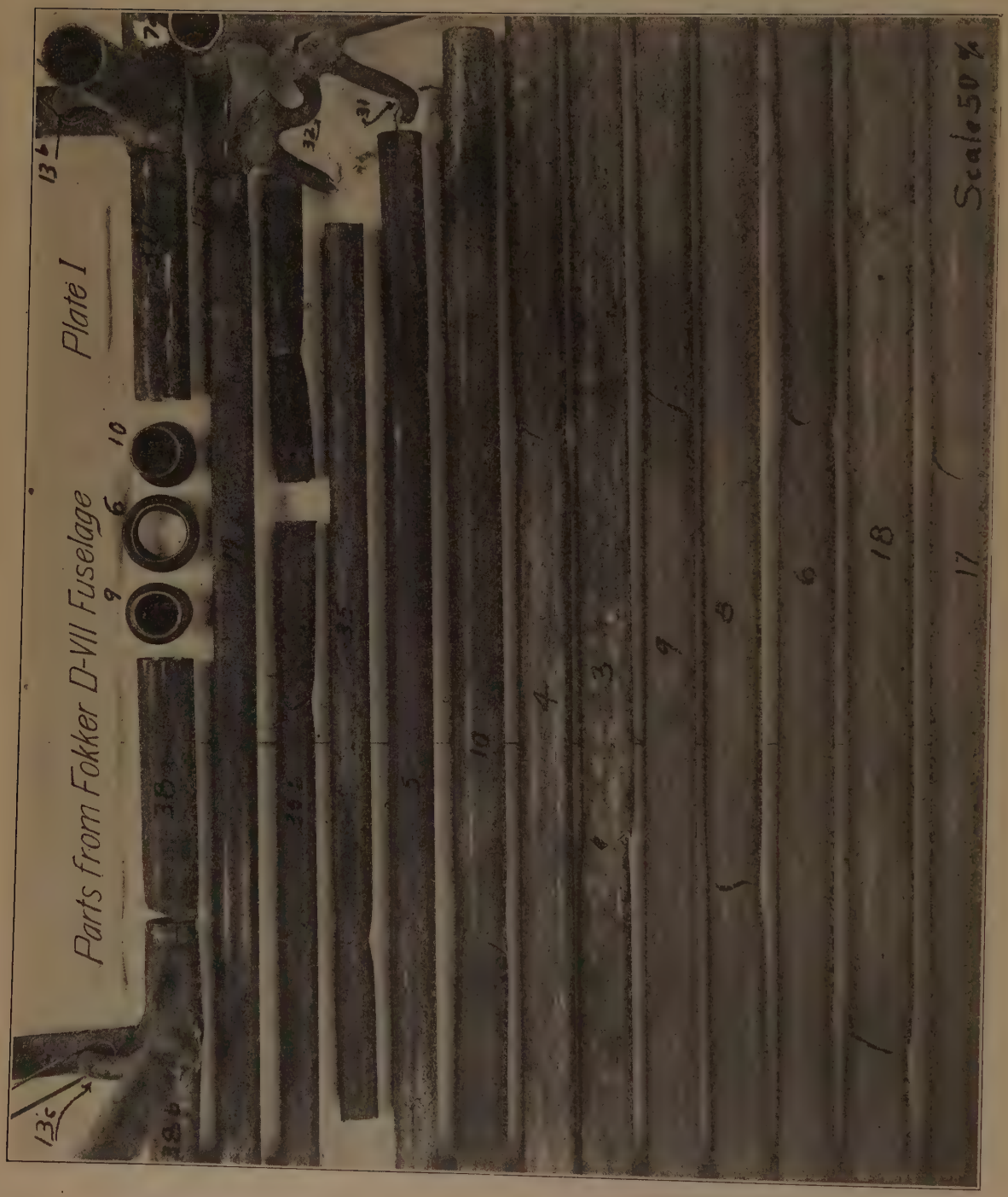


FIG. 3

Tubing—Round, Clear, Straight Specimens. Figures 2, 3 and 4

General Description—						
Number of Specimen	3	4	6	8	18	17
Description of Specimen	Upper Longeron			Strut	Tubing	
Station	9-10	8-9	7-8	7	Strut in Engine Bay	
Gauge Thickness, Ins.	.045	.045	.048	.045	.040	.045
Outside Diam., Orig., In.	.716	.714	.793	.797	.868	.970
Inside Diam., Orig., Ins.	.626	.624	.697	.707	.788	.880
Thickness, 2 x gauge, Ins.	.090	.090	.096	.090	.080	.090
Cross Sectional Area, Orig., Sq. Ins.	.09487	.09458	.11234	.10631	.10405	.13077
Tension Test—						
Yielding Point, Lbs.	4,140	3,620	5,250	7,280	5,250	7,200
Yielding Point, Lbs./Sq. In.	43,640	38,274	46,733	68,479	50,457	55,058
Maximum Load, Lbs.	7,115	7,150	6,430	8,040	7,385	12,460
Ult., Str., Lbs./Sq. In.	75,000	75,600	57,240	75,630	70,980	95,280
Elongation, % in 8″	3.5	3.5	8.1	3.1	5.0	9.6
% in 4″	4.75	5.5	11.2	4.2	7.7	12.5
% in 2″	9.0	10.0	15.0	6.0	12.5	18.5
	——	O.K.	Cracks	Cracks	O.K.	O.K.
Location of Fracture	O.S.T.	O.S.T.	O.S.G.	M.T.	I.G.	O.S.T.
Character of Fracture	Jagged	Jagged	Diag. Jag.	Sq. Jag.	Jagged	Jagged
Compression Test—						
(1½ x Diam.) 1	1.071	1.071	1.190	——	——	——

Straight Streamline Tubing.

Tension Test—Specimen 14a, Figure 4

The right front inner wing strut of streamline steel tubing was tested in tension, the ends of the tube being plugged for gripping in the machine. The yield was well distributed along the whole length up to the point of failure, showing uniform quality.

Number of specimen	14a
Description of specimen	Streamline strut
Gauge of thickness	.038″
Gauge length	27.000″
Major axis	2.113″
Minor axis	.889″
Perimeter	4.500″
Cross sectional area, original	.1710 sq. in.
Yielding Point	8,500 lbs.
Yielding Point	49,710 lbs./sq. in.
Maximum load	11,720 lbs.
Ultimate stress	68,540 lbs./sq. in.
Elongation, % in 8″	19.6
% in 4″	26.5
% in 2″	37.5
Location of fracture	Middle third
Character of fracture	Jagged

Parts from Fokker D-VII Fuselage
Plate III
14a
2
16b
15
23
23a
Scale 32 %
D.M.W.

FIG. 4

Strut Test—Specimen 14b, Figure 4

The right middle inner wing strut of streamline steel tubing (same as 14a) was given a strut test.

Number of specimen	14b
Description of specimen	Streamline strut
Gauge length	41.37 "
Gauge thickness	.038"
Major axis	2.113"
Minor axis	.889"
Perimeter	4.500"
Cross sectional area, original	.1710 sq. in.
Maximum load	4,700 lbs.

Curve Data

Load	Deflection	Load	Deflection
1000	0.000"	3400	.115"
2000	.065"	3600	.125"
2200	.070"	3800	.140"
2400	.075"	4000	.150"
2600	.080"	4200	.170"
2800	.085"	4400	.195"
3000	.090"	4600	.235"
3200	.100"	4700	.325"
		4750	.950"

Welds and Joints, Specimen 1, Figures 3 and 4

Weld of tail post to upper longerons. Specimen was pulled to test weld. The tube began yielding below weld, and longerons sheared with no signs of weakness in weld.

Number of specimen	1
Description of specimen	Tubing Joints
Outside diameter of tail post, original	.871"
Inside diameter of tail post, original	.783"
Thickness of tail post, 2 x gauge	.088"
Cross sectional area of material in tail post, original	.11432 sq. in.
Maximum load	6000 lbs.

Experimental

Specimen 2, Figures 3 and 4

Weld of tail post to lower longerons. Specimen pulled to test weld. The tail post failed, while the weld showed no weakness.

Number of specimen	2
Description of specimen	Tubing, welded
Outside diameter of tail post, original	.871″
Inside diameter of tail post, original	.783″
Thickness of tail post, 2 x gauge	.088″
Cross sectional area of material in tail post, original	.11432sq. in.
Maximum load	7320 lbs.
Ultimate stress on tail post	64,030 lbs./sq. in.

Specimens 13a, 13b, 13c, Figure 3

Tubular anchor loop No. 13a was pulled to failure by two wires pulled simultaneously from loops No. 13b and 13c as assembled in the fuselage. Loop No. 13a collapsed and tore out, but No. 13b, and No. 13c held. The longeron sections were plugged for the test.

Location of specimens—

No. 13a was from lower left station 7.
No. 13b was from lower right station 6.
No. 13c was from lower right station 8.
Diameter of wires doubled .059″.
Maximum load 2820 pounds.

Specimen 15, Figure 4

Group weld at union of left rear wing tripod strut with upper longeron at station No. 2. Strut was of streamline steel tubing. The strut and attached members were plugged to prevent collapse, and tested in tension. The strut failed at edge of weld, showing weld firm and steel softer at that point.

Number of specimen	15
Description of specimen	Streamline strut
Gauge length	27″
Gauge thickness	0.038″
Major axis	2.113″
Minor axis	0.889″
Perimeter	4.50″
Cross sectional area, original	.1710 sq. in.
Yielding point	6000 lbs.
Maximum load	8575 lbs.
Elongation, % in 2″	4.5
% in 1″	6.0

Specimens 16a, 16b, 16c—Figure 4

Specimens from right engine bearer.

16a failed in tension at edge of weld, showing weld stronger than tube.

16b failed at edge of weld in strut test, showing steel softer near weld.

16c gave satisfactory compression results.

	Tension	Strut	Compression
Number of specimen	16a	16b	16c
Description of specimen	Tube with welds in middle		Tube Stub 2.063″
Gauge length, inches	8	19	2.063
Outside diameter, original, ins.	1.340	1.340	1.340
Inside diameter, original, ins.	1.218	1.218	1.218
Gauge thickness, original, ins.	0.061	0.061	0.061
Area, original, sq. ins.	0.25674	0.25674	0.25674
Yielding point, lbs.	13,000	———	———
Yielding point, lbs./sq. in.	50,630	———	———
Maximum load, lbs.	15,650	12,500	17,400
Ult. Str., lbs./sq. in.	60,960	48,690	67,770
Elongation, % in 8″	4.5	———	———
% in 4″	7.5	———	———
% in 2″	13.5	———	———
Location of fracture	Beside the weld	———	———
Character of fracture	Jagged	———	Fine cracks
Notes:		Failed in compression both sides of weld. Steel softer there.	Standard compression test.

Specimen 19—Figures 2 and 3

Right strut at station 9 complete with welded joints at top and bottom; pulled to test welding. The specimen was pulled by steel cross plugs inserted in the longeron sections at either end of the tube. The tube broke at 19a (Fig. 2), and also showed yield at 19b (Fig. 2), proving steel to be softer near welds. The welding showed no weakness.

Number of specimen	19
Description of specimen	Tube with welds at ends
Outside diameter, original	.590″
Thickness, 2 x gauge	.041″
Cross sectional area, original	.07072 sq. in.
Yielding point	3,440 lbs. 48,640 lbs./sq. in.
Maximum load	4,160 lbs.
Ultimate stress	58,820 lbs./sq. in.
Location of fracture	Edge of weld
Character of fracture	Cup

Experimental

Specimen 20—Figure 4

Specimen from rudder mast given torsion test. Failure occurred in weld inside of sleeve where rib tubes and sleeve were welded to mast. Ends of tubes were plugged for test.

Number of specimen	20
Description of specimen	Rudder Post Tubing
Gauge thickness	.034″
Gauge length	10″
Outside diameter, original	1.38″
Inside diameter, original	1.312″
Thickness, 2 x gauge, original	.068″
Number of turns	2
Cross sectional area, original	.1438 sq. in.
Maximum load	1600 (in. lbs.)
Maximum load after yield	750 lbs.

Note—Steel proved to be softer near welds.

Specimen 23—Figure 4

Apex of left inner wing tripod struts. Center strut plugged and gripped so as to allow pulling of union at top by a bolt through hole. The hole was normal to, and located entirely within the strut. It tore out, which showed that the steel was weakened at weld.

Number of specimen	23
Description of specimen	Streamline strut
Gauge length	27″
Gauge thickness	.038″
Major axis	2.113″
Minor axis	.889″
Perimeter	4.50″
Cross sectional area, original	.1710 sq. in.
Yielding point	8,000 lbs.
Maximum load	8,035 lbs.

Specimens 31 and 32—Figure 3

Group weld same as Specimen 41. Tubular anchor loops for truss wires at Station No. 9. A steel plug was inserted through the longeron section to hold the joint while loop No. 31, and then No. 32, were pulled to failure by means of cables in an Olsen Testing Machine. The tubing failed and the welds held. This test was made after tube No. 19 was pulled.

Number of specimen	31 and 32
Yielding point	1,340—3,240 lbs.
Maximum load	3,550—4,120 lbs.

Specimens 37a and 37b—Figure 2

Longeron reduction splice at lower right station No. 6. Specimen pulled as single tube to test weld. In test of 37b the inserted tube broke at edge of weld. It showed severe burning, there being an accumulation on its inner surface. 37a showed some yield at edge of weld.

Number of specimen	37a	37b
Description of specimen	Longeron tubing spliced at station	
Outside diameter, original, ins.	.869	.784
Inside diameter, original, ins.	.789	.698
Thickness, 2 x gauge, ins.	.040	.043
Area, original, sq. in.	.10418	.10010
Yielding point, lbs.	4,100	4,100
Yielding point, lbs./sq. in.	——	40,960
Maximum load, lbs.	4,900	4,900
Ultimate stress, lbs./sq. in.	——	48,950
Location of fracture	——	Edge of weld
Character of fracture	——	Square break
Note:	Large tube showed some yield.	Small tube broke. Burned in weld.
Elongation, % in 2"	6.5	6.5

Specimens 38a and 38b—Figure 2

Longeron reduction splice at lower right station No. 8. Specimen pulled as single tube to test weld. In test of 38a the outer tube broke at edge of weld, showing signs of burning. 38b yielded nearly to failure.

Number of specimen	38a	38b
Description of specimen	Longeron tubing spliced at station.	
Outside diameter, original, ins.	.784	.721
Inside diameter, original, ins.	.698	.634
Thickness, 2 x gauge, ins.	.043	.047
Cross sectional area, original, sq. ins.	.10010	.09259
Yielding point, lbs.	4,000	4,000
Yielding point, lbs./sq. in.	39,960	——
Maximum load, lbs.	6,000	6,000
Ultimate stress, lbs./sq. in.	59,940	——
Elongation, % in 2"	4	4

Welded Specimens Not Tested—Figure 4

Specimen 40—Reduced end of streamline strut with eyebolt.
Specimen 41—Welded union at station No. 9. Loops same as 31 and 32.
Specimen 42—Longeron offset splice and union with struts and loops at right upper station No. 8. Bolt to hold horizontal stabilizer.
Specimen 43—Angle brace and cross strut union weld at top of cockpit.
Specimens 44, 45, 46, 47, and 48—Various welded clamps for attaching parts and equipment to fuselage.
Specimen 50—Bronze turnbuckles. Wires and wire ferrules. No solder.

Experimental

Photographs.

Figures 2, 3 and 4—Specimens after physical test.

Figure 5—General assembly: Side view, showing general structure and proportion.

Figure 6—General assembly: Front view, showing the engine cavity and the lateral tripod arranged inter-plane struts, which are welded to the fuselage.

Figure 7—Special side view, showing construction of tank and cockpit bays.

Observations.

All tubing was rusted on the outside where enamel was removed.

The inside of all closed tubes was clean and free from rust, which tends to prove that tubing will be best protected if left sealed, where possible.

All tubing was cut to fit and then welded together so skillfully that the inside of the finished tubes, save in those cases previously mentioned as "burned," showed practically no signs of the welding.

In all telescoping joints the smaller tubes had four slits the full length of the insertion.

Apparently no high-grade steel tubing was used.

METALLURGICAL BRANCH.

Photography—One plate and five microphotographs are included in this report, which have the following description:

Figure	Magnification	Observations
8	0.9 Diameters	Plan view of welded joint.
9	100.0 "	Welded joint, showing welding material (upper left), oxide-sulphide—silicate boundary, and the tubing material (below impurity line). Specimen No. 1.
10	100.0 "	Structure of tubing at weld. Specimen No. 1.
11	100.0 "	Finer, more uniform structure of the tubing farther removed from the weld than Fig. 10, Specimen No. 1.
12	100.0 "	Very fine structure of the tubing at a point where the temperature of welding was sufficient to anneal the steel. Specimen No. 1.
13	100.0 "	Cold drawn structure of tubing taken from central portion of horizontal strut, where none of the effects of welding are visible. This is the typical structure of the tubing (at a distance from the welds) of the entire fuselage.

Metallography—Figure 9 shows the nearly pure ferrite of the welding material just above the dark colored streak of impurities, which consists of manganese sulphide, silicates, and oxides introduced by the welding process. Below the impurity streak is the structure of the tubing, the grains of which were coarsened by the high temperature employed during welding. Figure 10 is also illustrative of the structure of the tubing at the weld. The effect of the lower temperature at a point more removed from the weld is to be seen in Figure 11. The grains are smaller, and the structure more uniform than that shown in the preceding microphotographs. Still farther from the focus of the weld, the temperature was considerably lower, resulting in the very fine grain structure of Figure 12. It will be noticed that the grains at the edge of the tubing are coarser than those in the center. Figure 13 indicates the typical structure of the fuselage tubing wherever it was beyond the zone affected by the heat of welding. The effect of the cold drawing of the tubing was an elongation of the grains in the direction of drawing. The grains, as in Figure 12, are finer in the center than at the edges.

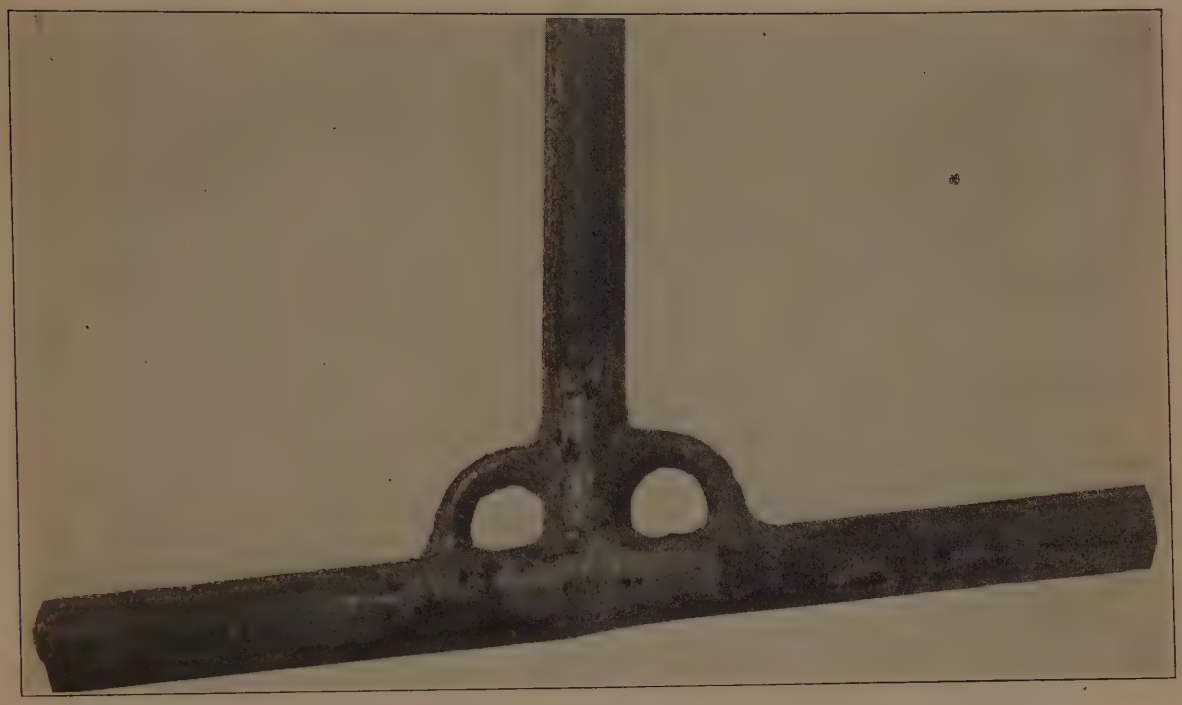


FIG. 8

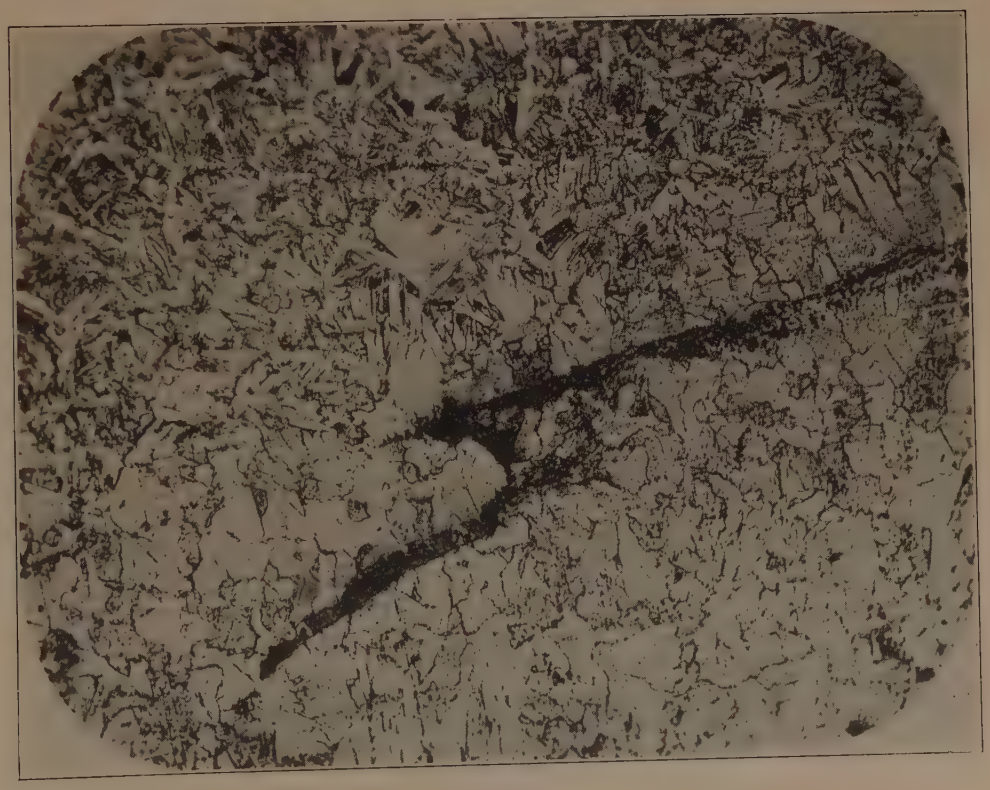


FIG. 9

FIG. 10

FIG. 11

FIG. 12

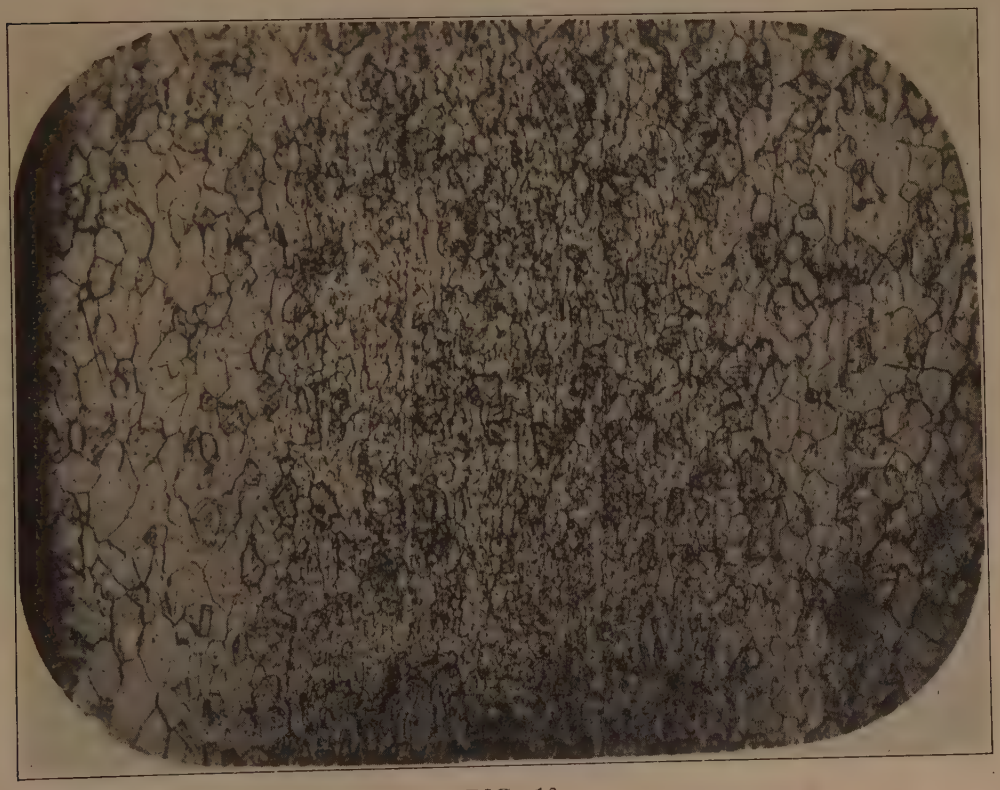


FIG. 13

Experimental

CHEMICAL BRANCH.

A chemical analysis made on samples from landing gear struts gave the following results:

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
Carbon	.22	.20	.18	.17
Manganese	.51	.38	.35	.35
Phosphorus	.033	.033	.039	.039
Sulphur	.078	.082	.084	.083
Nickel	.000	.000	.000	.000
Chromium	.000	.000	.000	.000
Vanadium	.000	.000	.000	.000

Discussion of Results

METALLURGICAL.

The tubing proper was heterogeneous, the carbon content varying from almost zero to fifteen points. The welding material was a steel practically free from carbon. Coarse etching (25 per cent aqueous sulphuric acid) revealed that the tubing was welded, not seamless.

In the manufacture of the tubing it appears that after the welding process the tubes were probably flash-annealed, that is, they were heated up to the annealing temperature with extreme rapidity. The result of this method of heat-treatment was to effect decarbonization of the exterior surfaces of the tubes, coarsening the grains at the edge, as the temperature at the exposed surfaces was somewhat higher than that necessary to produce the proper fine-grained structure of the interior. There is a distinct gradation in the grain size from the exterior to the central portion of the metal (Fig. 12), showing that the tubing was cold drawn.

In the subsequent welding operation, which bound the horizontal struts to the longeron tubing, the grains were coarsened and the distortion from cold drawing removed (Figs 10 and 11), but as the heat effect from the welding tapered off it reached a point in the tubing where it caused annealing (Fig. 12). The reason for the grains at the edge being coarser than those in the center is that this last portion contains more carbon, and, consequently, the temperature necessary to secure maximum refinement of the central structure was too low to affect similarly the outer portion.

From the persistence of the cold drawn structure shown in Figure 13 and the character of the structure about the weld (Figs. 9, 10 and 11) it is concluded that the fuselage was not heat-treated after welding.

The welding of the joints was carried out with the oxy-acetylene torch and conducted with extreme skill.

RESUMÉ OF McCOOK FIELD TEST REPORTS

AIRPLANE SECTION

Serial No. 1221

An empirical theoretical method of comparative prediction of airplane performances is given in this report. Certain full flight data, combined with considerations of loadings per horsepower and per square foot and fineness ratio, or the lift/drift ratio, are the basis of the computations. From these considerations a series of charts have been plotted, from which the complete performance of an airplane may be predicted with a reasonable amount of reliability.

Serial No. 1242

An application of the de Bothezat method of performance prediction and calculation was applied to full flight data on the VE-7 to show the process of application.

Serial No. 1249

A static test proved the tail surfaces of a G.A.X. satisfactory for this type of airplane. No changes were recommended.

ARMAMENT SECTION

Serial No. 1258

An inspection and test of the armament of the Thomas-Morse MB-3 proved it to be satisfactory, except for the following items:

1. The gun mount is not interchangeable, being designed for Browning guns only.
2. No fittings are provided for the mounting of bomb release mechanisms.
3. No Very pistol holster or Very pistol ammunition holder is provided.
4. No fittings or wiring are provided for the wing tip flare brackets.

Serial No. 1261

A series of tests of sights for flexibly mounted 37 mm. cannons proved that for firing at ground targets the ring and wind vane sights are the most satisfactory means of sighting at present available for a flexible cannon mount.

EQUIPMENT SECTION

Serial No. 1213

An airplane speaking tube for training use was designed and built by the Engineering Division. When used on the Curtiss JN-6 very satisfactory results were obtained. It is comfortable, simple to use, and has sufficient audibility for use on training airplanes.

Serial No. 1252

Test of an auxiliary radio telephone control, designed and constructed by the Engineering Division, showed that it considerably increased the adaptability and transmitting range of the standard airplane radio telephone set, type SCR-68. In addition to the regular operation of the set as a radio telephone, it permits the operation of this set as a buzzer modulated telegraph set, and as an undamped telephone set. In the latter case it gives a range far in excess of that obtained by telephony.

Serial No. 1264

The tanks contained in the sixth shipment of leakproof and fireproof tanks furnished by the Miller Rubber Company failed to withstand a firing test.

MATERIAL SECTION

Serial No. 1237

A series of tests to determine the wearing, and moisture resistance qualities of various materials now used in control cable guides, and the comparative effect of the different materials on the cable indicate the superiority of Formica or Micarta Bakelite. Red fiber guides are about equal in wearing qualities, but have a tendency to heat up the cable and swell under the action of moisture. All metal guides have a decided tendency to wear the cable.

Serial No. 1266

A test to determine the value of aluminite (an aluminum alloy manufactured by the Green Engineering Company, Dayton, Ohio) as a bearing metal proved it to be unsatisfactory.

POWER PLANT SECTION

Serial No. 1241

A performance test of the six cylinder Liberty Aviation Engine using a Mercedes type of intake header, equipped with one carburetor, and with two carburetors gave the following results:

With the single carburetor assembly the engine develops about six horsepower less at normal speed, and ten horsepower less at low speeds, than with the double carburetor assembly. The fuel consumption is materially greater with a single carburetor assembly than with two

carburetors, due possibly to the cold manifold adapter, and, consequently, poorer vaporization. It should be noted that at the normal speed the difference in horsepower is about 2%, and in specific fuel consumption about 16%.

Examination of the performance with the two assemblies reveals uniformly higher depressions in the headers equipped with the manifold adapter and one carburetor. Since the same intake headers were used with both assemblies in conjunction with carburetor settings giving best performance, this difference is probably attributable to the manifold adapter. It would also indicate that the difference in power output and fuel consumption is similarly attributable in large part to the manifold adapter.

Serial No. 1257

A test of a centrifugal oil cleaner for installation in Liberty-12 proved it to be very satisfactory. After a run of only one hour a considerable amount of very thick residue, containing appreciable amounts of grit, such as sand, carbon, and metallic particles was left in the cleaner bowl. More conclusive results will be obtained from a fifty-hour test, which is to be made with two engines, one equipped with the cleaner, and one without, by comparing the condition of the engines after the run.

PROPELLER SECTION

Serial No. 1274

A destructive whirling test was conducted on a propeller submitted by the Bureau of Steam Engineering, U.S.N., built by the American Propeller and Manufacturing Co., drawing PP-292. The propeller withstood an input of 600 H.P. for a period of ten hours with no condition of failure and is, therefore, considered safe for use in the airplane for which it was designed.

Serial No. 1246

A destructive whirling test of a propeller for the Ordnance Model "D" airplane with 300 H.P. Hispano-Suiza Engine proved it to be satisfactory. This propeller was built to drawing X-22559.

RESUMÉ OF FOREIGN DATA

RESUMÉ OF FOREIGN DATA

BRITISH

PHOENIX No. VII FLYING BOAT
LONG RANGE PATROL OR PASSENGER CARRIER

A short time previous to the enactment of the Armistice the English Government decided to build huge flying boats for use in long range patrol work in the North Sea, to assist the dirigibles which were being used, and if the flying boats proved successful to supplant the dirigible entirely.

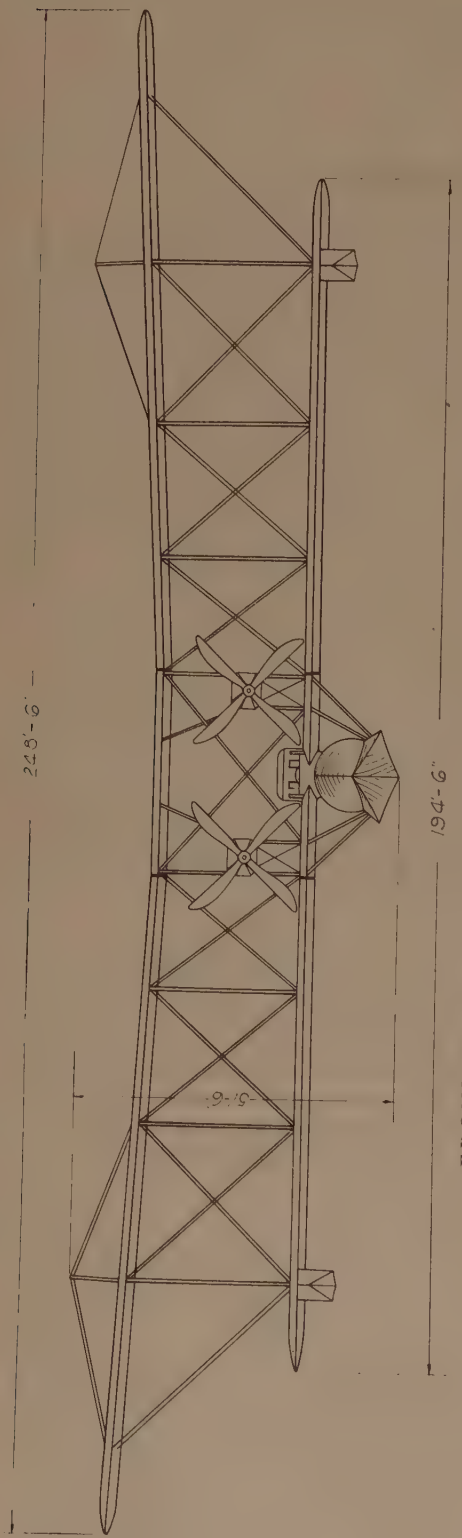
One of the most interesting of these large flying boats is the one constructed by the Phoenix Dynamo Company, from the design of the Fairey Aviation Company at Hayes, Middlesex. This boat is the largest of its type ever constructed and embodies various novel features, such as the arrangement of the eight engines in the nacelles, the large four-bladed propellers, and the extreme size of the hull.

After the Armistice was signed it was decided to convert or modify this large boat into a commercial product, and this article will deal with the latter type.

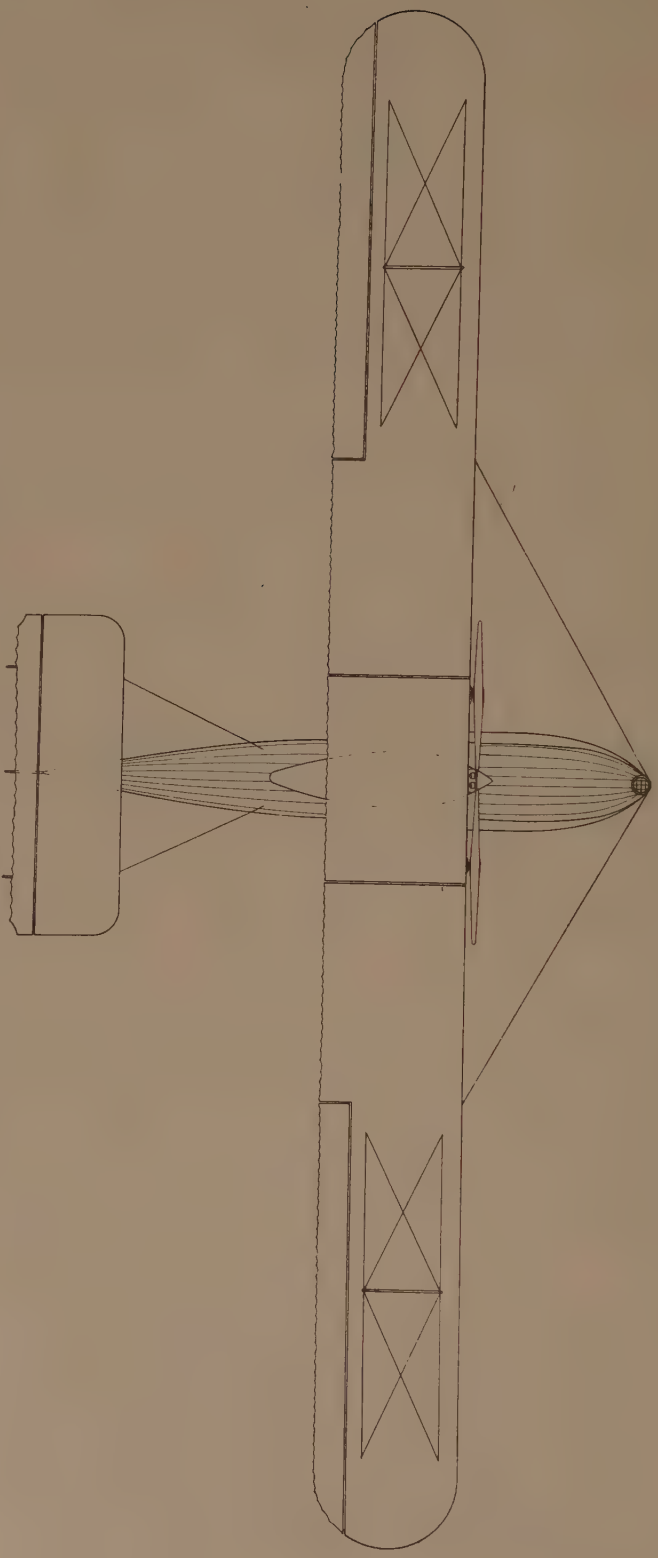
The hull of the boat, which is the largest that has ever been constructed, with the exception of the large multi-plane Caproni passenger carrying flying boat under construction at the present time, was built by the Gosport Aircraft Company. The inside of the hull is divided into various compartments as shown in Fig. 1. The front, bottom and rear compartments are all water tight. The main fuel and oil tanks are carried in the bottom compartment, and have a capacity of 4,000 gallons and 220 gallons respectively. This loading of fuel and oil with full load of crew, passengers, etc., affords an endurance of twelve hours at 86 M.P.H.

The wings are of conventional construction fitted to fold back, and beyond the engine nacelles have considerable dihedral, but no sweepback. The overhang of the upper wings is 27 feet on each side. This overhang is braced in the ordinary manner by diagonal struts from the lower wing, and cabane struts and wires on the upper surface of the top wing. Between the front and rear cabane struts a vertical slip fin is located. Large ailerons are fitted on the upper wing only. Each engine nacelle is supported from the lower wing by four vertical struts, two outside struts being continuous from the lower to upper wings. The nacelle is further braced by two diagonal struts from the upper wing and cross braced beneath the nacelle by two diagonal struts. The center section of the lower wings are braced from the hull on each side by four struts.

Each of the engine nacelles contain four 600-H.P. Rolls-Royce "Condor" engines totalling 2400 H. P. for each group. Each group of engines is connected as one unit through a reduction gear, to a single four-bladed propeller 25 feet in diameter, which rotates at 500 R.P.M. Each engine is connected to the main drive gear by means of a friction clutch, and it is possible by this arrangement, under normal conditions of flight, to permit of three engines running partially throttled, or two engines on full throttle, and still drive the propeller at proper speed. One engineer, or mechanic, will be located in each nacelle, thereby permitting minor repairs to be made on the engines while in flight, and it is also possible for additional mechanics to gain access to the nacelles to assist in repairs.



FRONT ELEVATION OF PHOENIX No. VII FLYING BOAT



PLAN OF PHOENIX No. VII FLYING BOAT

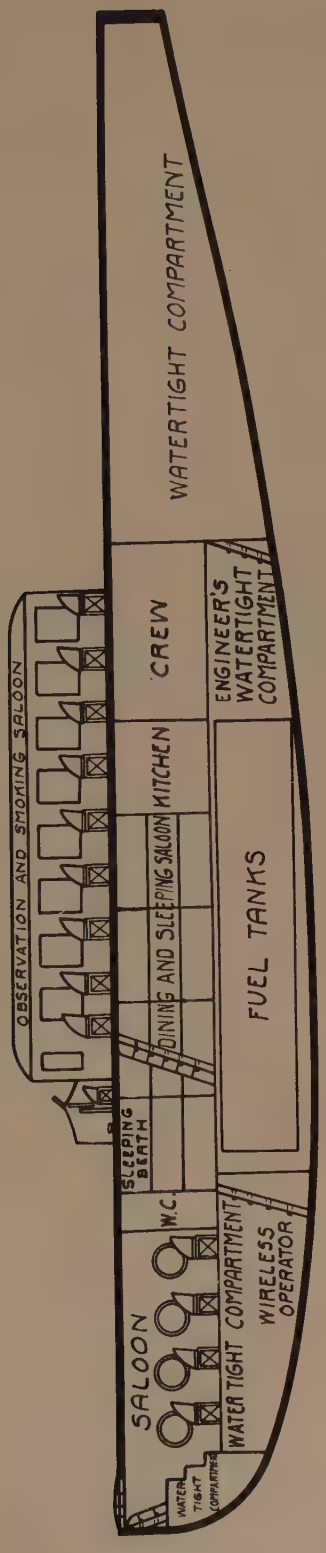
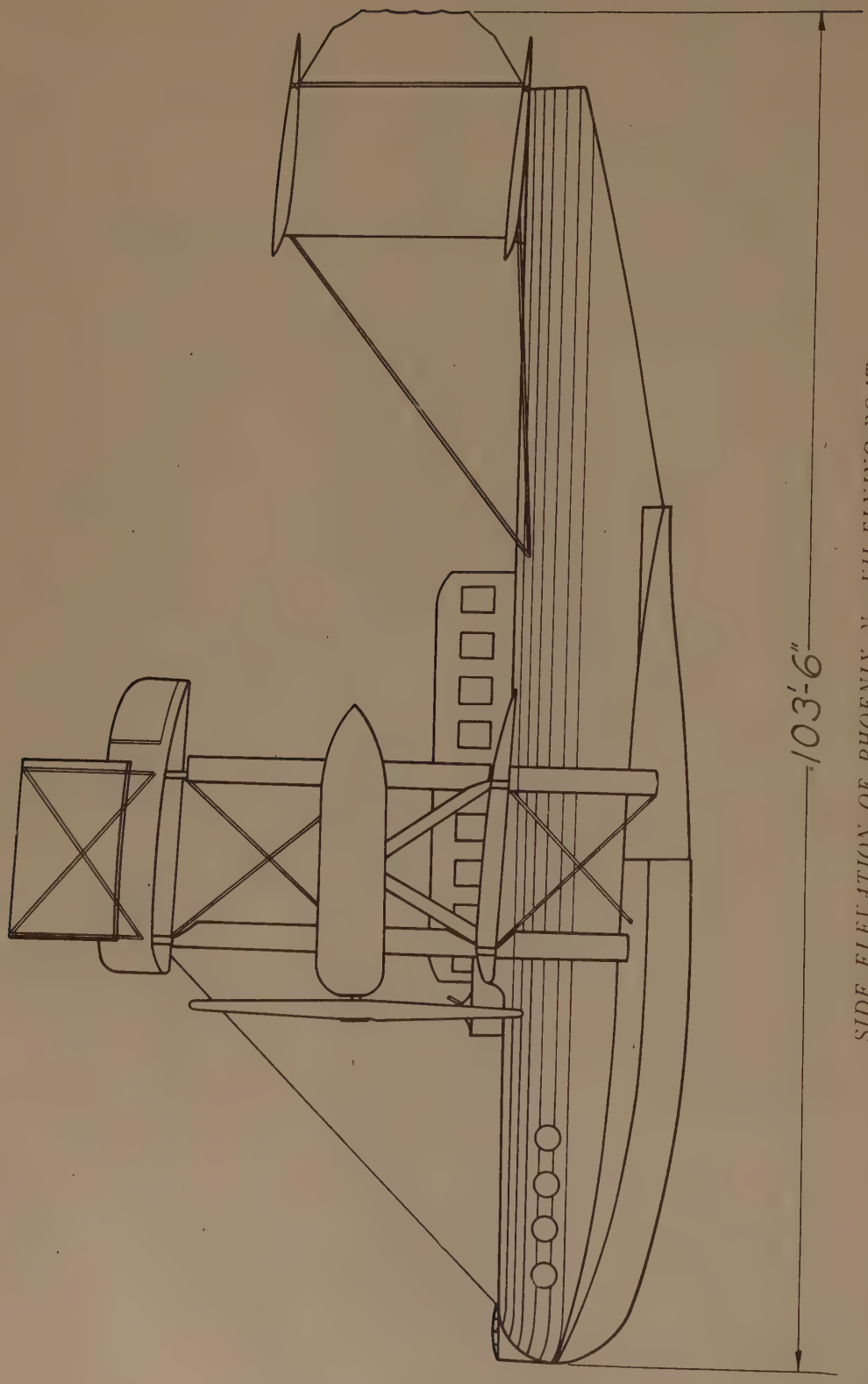

WATERTIGHT COMPARTMENT
CREW
ENGINEER'S WATERTIGHT COMPARTMENT
KITCHEN
DINING AND SLEEPING SALOON
OBSERVATION AND SMOKING SALOON
FUEL TANKS
SLEEPING BERTH
W.C.
SALOON
WATER TIGHT COMPARTMENT
WIRELESS OPERATOR
WATER TIGHT COMPARTMENT

FIG. 1



SIDE ELEVATION OF PHOENIX No. VII FLYING BOAT

The hull tapers to a vertical knife edge, and the conventional biplane empennage group is located on top of the hull at this point. It consists of two large horizontal stabilizers, three vertical fins, three rudders, the center one being balanced, and two unbalanced elevators.

The pilots' cockpit is located on top of the hull just forward of the upper passenger compartment. The controls are conventional, being in duplicate. A crew of six is provided, consisting of two pilots, three mechanics, and one radio operator.

Specifications

Overall span	248′ 6″	
Overall length	103′ 6″	
Overall height	51′ 6″	
Span, lower wing	194′ 6″	
Chord of wings—upper, lower	22′ 7″	
Wing Section—Flat undersurface $\frac{T}{C}$ = .0817 (No. 1—R. & M. 322)		
Aspect ratio wing—Upper	11:1	
Lower	8.6:1	
Total supporting area	10,000 sq. ft.	
Area empennage	1,840 sq. ft.	
Total weight fully loaded		100,000 lbs.
Lbs./sq. ft.	10	
Lbs./H.P.	20.8	
Load consists of crew of 6—		
50 passengers—luggage	2,500 lbs.	
Gasoline	4,000 gals.	
Oil	220 gals.	

Engines—

8—600-H.P. "Condor" Rolls-Royce 12-cylinder (V 60°) water cooled.

Propeller—

4-bladed, 25 feet diameter

Performance—

Full speed, sea level	100 M.P.H.
Cruising speed	85—90 M.P.H.
Climb, 1000 feet	4 minutes

ITALIAN

FIAT, TWELVE-PASSENGER AIRPLANE

The Fiat twelve-passenger airplane is the latest product of the Fiat Company. Its general outlines are similar to those of the BR and ABR type biplanes.

The main characteristics of this latest product are the combined triple engine apparatus, driving one large tractor propeller, proximity of the pilot and the mechanic to the power units, the large passenger compartment, the high speed of such an airplane, and the four-wheel landing gear.

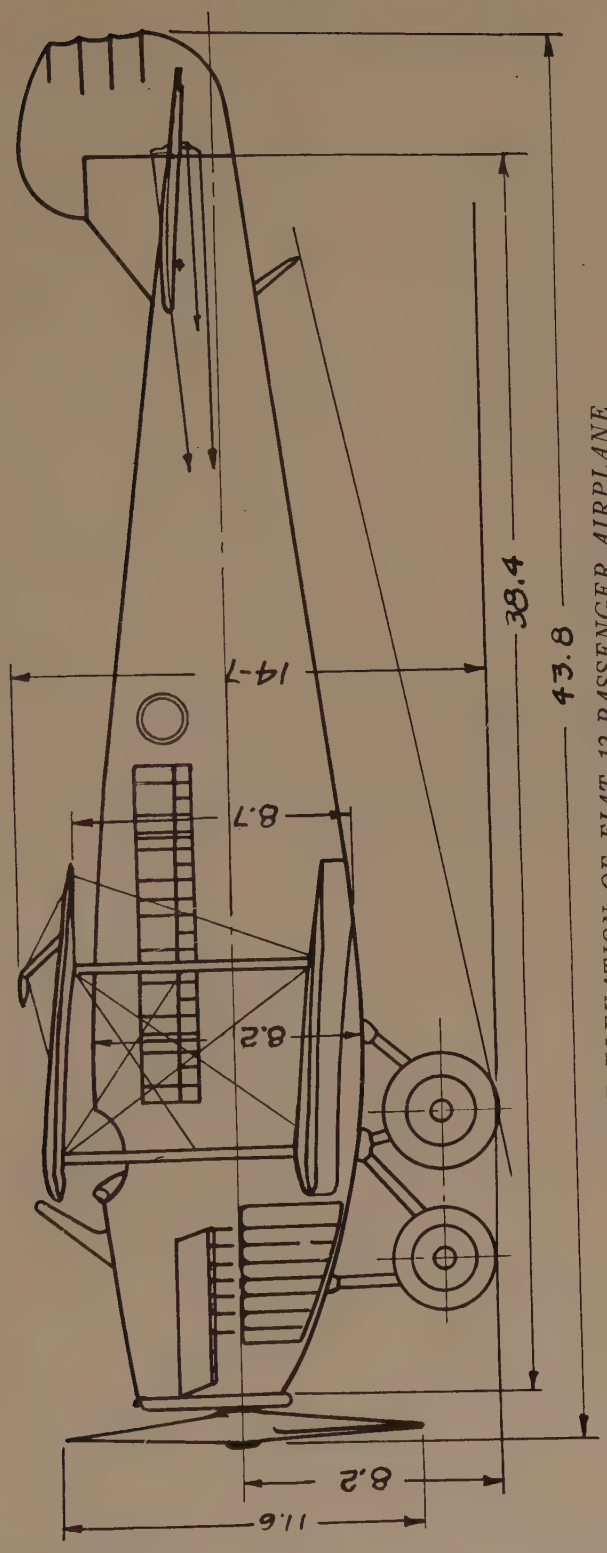
The three engine apparatus minimizes the danger of crash due to engine failure, but the largest factor in favor of its use is the rotation of the large air screw at its most efficient speed. The engagement and disengagement of the three engines is taken care of automatically, or may be controlled by the pilot, who can alternate and combine as necessary. The failure of one of the engines results only in a decrease in the R.P.M. of the propeller, and in the speed of the airplane. As a very low flying speed is able to maintain this airplane in the air, there is a possibility of two of the engines failing and the airplane still maintaining level flight. This is due to the fact that when the three engines are working together they produce a higher horsepower than is required in normal flight. This permits of a large factor of safety in regard to the engines, the factor of safety of the power unit being eight.

The fuselage is very strongly constructed, and ample space is provided for the passengers and installation of large fuel tanks, the latter being so located that in the event of a crash there is no danger of them crashing in on the passengers' compartment.

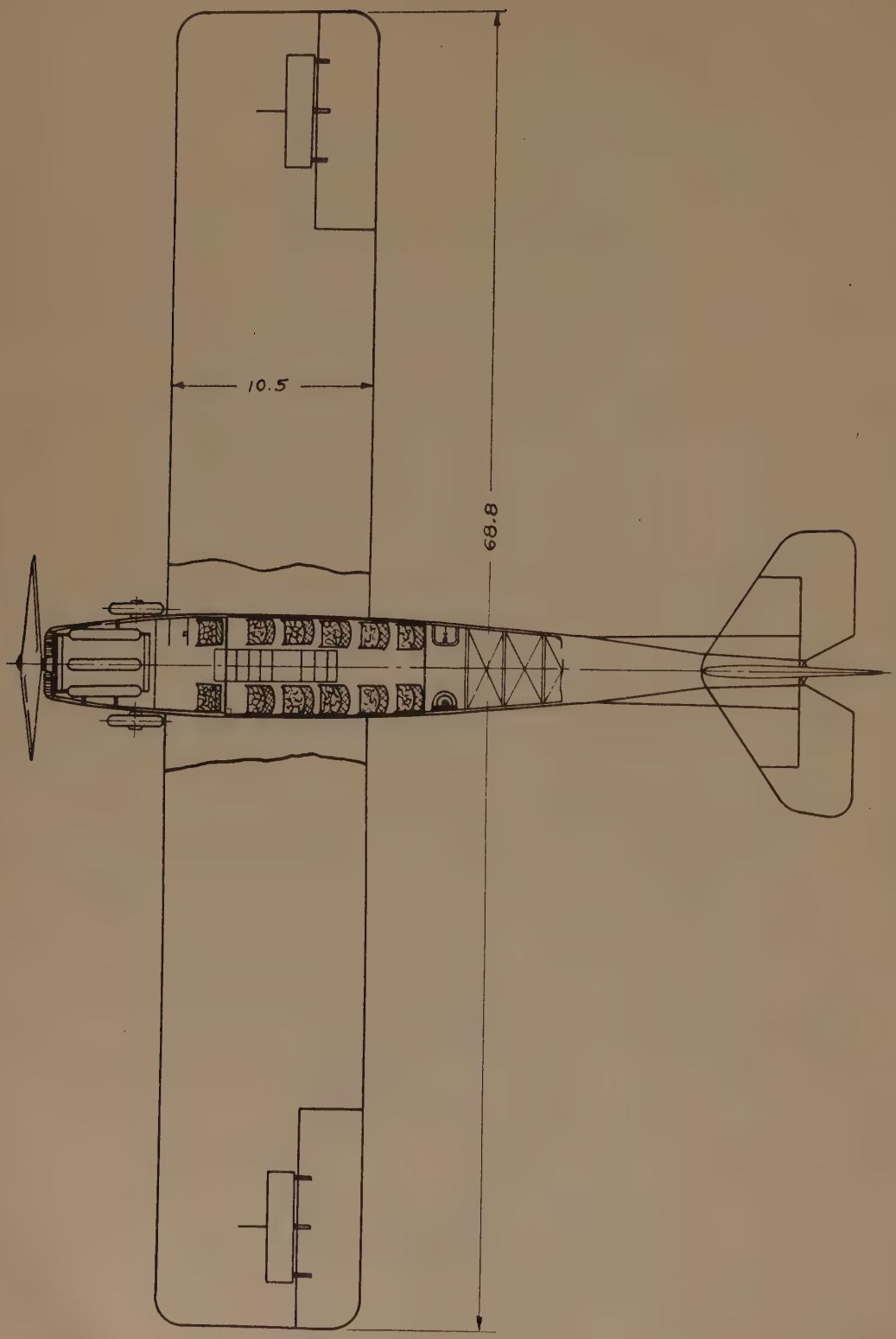
The wings are of the conventional Fiat construction, modified to a larger scale. The upper wing is built in one section, permitting the use of a rigid spar, which increases the life of the wing, and allows a reassuringly strong aspect ratio, and a better streamline shape. The upper wing has no dihedral, but the lower wing is set at an angle of two degrees. Ailerons are fitted to the upper wing only, and are balanced by small auxiliary planes, as on the Fiat BR, and ABR airplanes.

There are two sets of "V" type two-wheel landing gears, the rear one being located directly under the center of gravity of the airplane, and the front one forward of this position, and under the engine. The four-wheel landing gear in connection with the low minimum speed insures easy and safe landing.

The empennage is of conventional design and construction. Elevators and rudders are balanced.



SIDE ELEVATION OF FIAT 12-PASSENGER AIRPLANE



PLAN OF FIAT 12-PASSENGER AIRPLANE

Specifications

Overall span	68.8′	
Overall length	43.8′	
Overall height	38.4′	
Wing span—Upper	68.8′	
Lower	68.8′	
Chord of upper and lower wings	10.5′	
Gap (at wing root)	8.4′	
Dihedral, lower wing	2°	
Stagger	None	
Depth of fuselage	8.2′	
Height of propeller axis from ground (flying position)	8.2′	
Weight empty		7,040 lbs.
Useful Load—		
Fuel and oil	1,650 lbs.	
Equipment and Radio apparatus	110 lbs.	
Crew	330 lbs.	
10 passengers and luggage	1,870 lbs.	
Total	3,960 lbs.	
Weight loaded		11,000 lbs.
Power of engine apparatus—Maximum	1,850 R.P.M. 900 H.P.	
Normal	1,600 R.P.M. 700 H.P.	
Performance—		
Speed—Maximum	125 M.P.H.	
Minimum	60 M.P.H.	
Endurance	600—750 miles	

operty of Lillian Michelson
LM 00003617